Illinois
State Geological Survey

STATE OF ILLINOIS
STATE GEOLOGICAL SURVEY
FRANK W. DEWOLF, Director

BULLETIN No. 33

YEAR BOOK FOR 1915

ADMINISTRATIVE REPORT

AND

ECONOMIC AND GEOLOGICAL PAPERS

Work in cooperation with U. S. Geological Survey

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS
URBANA
1916

REVIEW
PRESS
DECATUR, ILL.

LETTER OF TRANSMITTAL

State Geological Survey,
University of Illinois, November 3, 1916.

Governor E. F. Dunne, Chairman, and Members of the Geological Commission,

Gentlemen:—I submit herewith my administrative report for the fiscal year ended June 30, 1916, accompanied by miscellaneous papers of economic interest, and recommend that they be published as Bulletin No. 33.

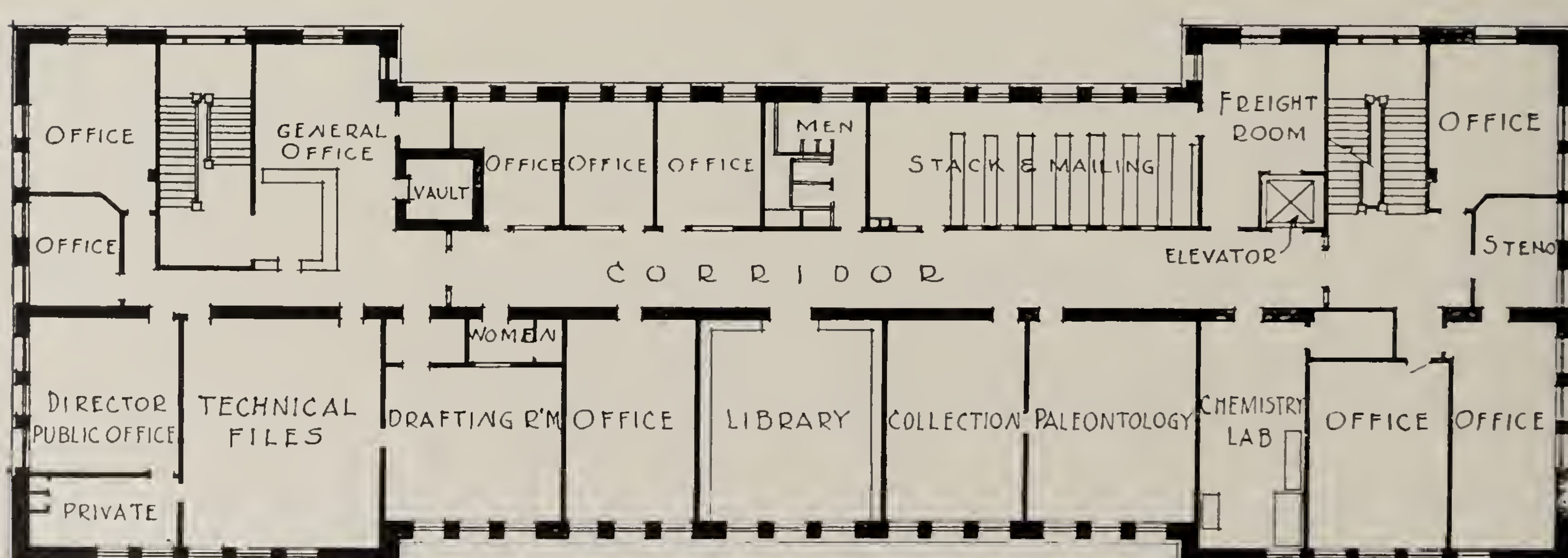
Three of the papers have appeared as extracts from this bulletin, but the report on mineral resources of Illinois in 1915 and the oil reports for the Birds and Vincennes quadrangles are published for the first time.

Very respectfully,

Frank W. DeWolf, *Director.*

CONTENTS

View of the Ceramics Building, University of Illinois, Urbana.



Plan of third floor, Ceramics Building, occupied by the Illinois State Geological Survey.

ADMINISTRATIVE REPORT FROM JULY 1, 1915 TO JUNE 30, 1916

By F. W. DeWolf, Director

OUTLINE

PLATE

TABLE

Introduction

GENERAL STATEMENT

During the fiscal year 1915-1916, the Geological Survey completed a large amount of work on coal, oil and gas, ground water, clay, drainage, and educational bulletins. The usual amount of topographic mapping was done.

The office was moved at the close of the year to the new Ceramics Building at the University, where ample space is provided for office, library, and laboratory work of all kinds. The beauty of the building and the practical arrangement of rooms are illustrated by the frontispiece. The Survey is now better housed than any State Survey, and will doubtless be better able to work efficiently and economically.

ORGANIZATION AND PERSONNEL

The Survey included a general office section and two technical sections,—Geologic and Topographic, as before. Cooperation was maintained with the U. S. Bureau of Mines, two engineers of which are located at Urbana. The geologic section was administered by F. W. DeWolf, Director, and F. H. Kay, Assistant Director. The topographic section was in general charge of R. B. Marshall, Chief Geographer, U. S. Geological Survey, until his appointment as Superintendent of National Parks and the appointment of Sledge Tatum as Acting Chief Geographer. After the death of Mr. Tatum the work of administration was taken up by W. H. Herron, former Geographer of the Central Division for the U. S. Geological Survey, who was appointed Acting Chief Geographer. The U. S. Bureau of Mines is represented by H. I. Smith and J. R. Fleming, under the general supervision of G. S. Rice.

Miss C. H. Thory acted in the capacity of Chief Clerk, assisted by Miss Faith Neighbour, as stenographer and clerk.

Professors Salisbury, Grant, and Barrows continued to serve as consulting geologists, and professors Parr and Bartow as consulting chemists. R. T. Stull, Ceramist, was in general charge of the clay studies until he resigned from the University of Illinois to accept a private position; his work was taken up by R. K. Hursh.

Professors Weller, Savage, and Salisbury have given part time service to the Survey as geologists. G. H. Cady, Assistant Geologist, spent one month on the study of the La Salle anticline and the remainder of his time has been divided between quadrangle work and mining studies. Wallace Lee of the U. S. Geological Survey mapped the Shawneetown and part of the Equality quadrangles in cooperation with the State Geological Survey. Fred H. Kay, Assistant State Geologist, completed a report on the coal resources of the Danville district. He then took up the oil work of

the Survey and spent two months in the field for a report on the oil industry. A considerable amount of his time was given over to administrative work. T. E. Savage and J. L. Rich made new surveys of the Birds and Vincennes quadrangles and revised work on the Hardinville and Sumner quadrangles. C. B. Anderson continued work on artesian water resources of northeastern Illinois and submitted his report at the end of the year.

Coal analyses and various chemical studies were carried on by J. M. Lindgren and D. F. McFarland, chemists, under the general direction of Professor Parr of the University of Illinois. Helen Skewes, Assistant Geologist, continued in charge of the technical files and of editing Survey publications. W. S. Nelson acted as Draftsman and Engineer.

A number of other men served for short periods of time in the field and office. The organization of the Survey was as follows:

COMMISSIONERS

Governor E. F. Dunne, Chairman
Professor T. C. Chamberlin, Vice-Chairman
President E. J. James, Secretary.

ADMINISTRATIVE WORK

F. W. DeWolf, Director
Fred H. Kay, Assistant State Geologist
C. H. Thory, Chief Clerk

GEOLOGICAL SECTION

F. W. DeWolf, Geologist
R. D. Salisbury, Consulting Geologist
U. S. Grant, Consulting Geologist
Harlan H. Barrows, Consulting Geologist
S. W. Parr, Consulting Chemist
Edward Bartow, Consulting Chemist
Stuart Weller, Geologist
T. E. Savage, Geologist
Fred H. Kay, Geologist
G. H. Cady, Geologist
C. B. Anderson, Assistant Geologist
J. L. Rich, Assistant Geologist
W. C. Morse, Assistant Geologist
Helen Skewes, Assistant Geologist
Wallace Lee, Assistant Geologist
R. T. Stull, Ceramist
R. K. Hursh, Ceramist
J. M. Lindgren, Chemist
D. F. McFarland, Chemist
W. S. Nelson, Engineering Draftsman
M. K. Read, Field Assistant
J. H. Bell, Field Assistant
E. F. Rehnquist, Field Assistant
O. F. Brooks, Office Assistant

S. T. Wallage, Office Assistant
P. T. Primm, Office Assistant
Faith Neighbour, Clerk

TOPOGRAPHIC AND DRAINAGE SECTION

The following members of the United States Geological Survey were engaged in the field work under cooperative agreement:

Topographic mapping—

C. W. Goodlove, Topographic Engineer
Gilbert Young, Topographic Engineer
J. A. Duck, Assistant Topographer
F. W. Hughes, Assistant Topographer
J. M. Rawls, Assistant Topographer
R. L. Harrison, Assistant Topographer
L. L. Lee, Assistant Topographer
R. M. Herrington, Junior Topographer
M. A. Roudabush, Junior Topographer
H. E. Burney, Junior Topographer
W. S. Gehres, Junior Topographer

Primary traverse—

J. H. Wilson, Assistant Topographer

Levels—

J. M. Rawls, Assistant Topographer
R. G. Clinite, Junior Topographer
J. M. Perkins, Junior Topographer
W. S. Gehres, Junior Topographer

COOPERATION

Formal cooperation with the U. S. Geological Survey has been maintained in the topographic work, in geological surveys on quadrangle areas, and in the collection of mineral statistics.

Drainage surveys along the Pecatonica River were completed also in cooperation with the U. S. Geological Survey. The U. S. Bureau of Mines and the Engineering Experiment Station, of the University of Illinois continued to cooperate with the Geological Survey in the publication of reports by the Illinois Coal Mining Investigations, the work of which was begun in 1912. The University of Chicago has kindly furnished office facilities for C. B. Anderson while writing his report.

From year to year the cooperation between the Survey and various coal and oil companies becomes closer and the results to the Survey more beneficial. The past year has witnessed a large amount of drilling, especially for oil; the information collected from various sources regarding the drill records will be of great value in adding to our knowledge of the underlying formations.

Geological Section

The administration of the geological section of the Survey has been in charge of the Director and the Assistant Director. A large amount of field work has been done and reports have been issued on coal, oil, lead, and zinc, and general educational topics.

GENERAL STATIGRAPHY

The Survey has persisted in its efforts to keep up to date on all of the drilling for oil, coal, and water. Arrangements have been made whereby the Ohio Oil Company notifies the Survey regarding the location of any new well being drilled for oil within the State, which greatly facilitates our securing records. Mr. Morse spent about two months in western Illinois collecting drill records from oil and water wells in counties bordering the Mississippi River. This work looks forward to additional field examination of western Illinois for oil and gas. Professor Weller continued studies of the Missisippian formations of southern Illinois and the adjacent parts of Kentucky under a cooperative arrangement of the Kentucky Survey and the U. S. Survey with that of Illinois. The work seems to establish a new classification which is satisfactory, but a further field conference is to be held during the coming season in order to adjust differences of opinion. Detailed mapping of the same area depends upon the success of these preliminary investigations.

One month was spent by Mr. Cady in a detailed examination of the LaSalle anticline in the northern part of the State. The results of this examination will probably be published in one of the year books. The stratigraphy of the Birds, Vincennes, Hardinville, and Sumner quadrangles was the subject of special examinations by Mr. Rich and Professor Savage. The manuscript for geological folios for these two sets of quadrangles was submitted to the U. S. Geological Survey for publication, and a State bulletin on the same area is now ready to be issued. The Coulterville quadrangle was practically finished by Mr. Cady, who has prepared a report for combination with a similar paper on the area immediately west.

COAL

A large amount of the work dealing distinctly with coal has been carried on by the Illinois Coal Mining Investigation, under a cooperative agreement between the State Geological Survey, the U. S. Bureau of Mines, and the Engineering Experiment Station of the University of Illinois. During the early part of the year a report by Fred H. Kay and K. D. White on the coal resources of the Danville district was published. A similar report for the Franklin, Williamson, and Jefferson County area by G. H. Cady is in press. A report of the Jackson County area by Mr. Cady is ready for publication, and another on the Saline-Gallatin County area

is being prepared by the same author. The new year's work will take care of similar reports of the Springfield-Peoria region and for the western Illinois area. After the completion of all the district reports it is planned to publish a summary report covering the coal resources of the entire State. This will be the most complete report of its kind ever published for Illinois.

Two reports on evidences of subsidence due to coal mining in Illinois have been written by L. E. Young. The first general report is being published by an arrangement with the Engineering Experiment Station. The second report, referring especially to Illinois, is ready for publication and will be sent to press early in the fall.

Detailed investigation of the coal in the Shawneetown and Equality quadrangles was undertaken by Wallace Lee of the U. S. Geological Survey, in cooperation with the State Geological Survey. The work was not completed and will be continued by Mr. Charles Butts of the Federal Survey during the field season of 1916. The resulting folio will be one of the most important yet published for Illinois.

Professor S. W. Parr submitted a manuscript for Bulletin No. 3 of the Illinois Coal Mining Investigation entitled "Chemical Studies of Illinois Coals." This book is in press at the close of the fiscal year and will be ready for distribution in the fall.

A report on clay material available at coal mines was submitted in September, 1915, but requires some additional work before publication on account of Prof. Stull's resignation from the University. The extra work will be undertaken by Mr. R. K. Hursh and it is expected that the bulletin will be distributed before January 1, 1917.

A coal mine map of Illinois was prepared and sent to the printer before the close of the fiscal year. The map contains all of the shipping coal mines in the State with a reference number to a list of mines printed on the same sheet. It is planned to distribute the map in November.

OIL AND GAS

Production of petroleum for the calendar year 1915 totaled 19,041,695 barrels with a value of $18,655,850 as compared with 21,919,749 barrels in 1914, with a value of $25,426,179. Inactivity marked the first half of 1915 until the rapidly advancing prices brought a response in development work during the final months of the year. The Staunton gas field, which was predicted by the Survey, was discovered early in 1915 and development work continued throughout most of the year.

The first half of 1916 witnessed a remarkable rise in the price of crude oil and a consequent increase in development work.

Mr. Kay spent two months in the oil fields of the State at the close of the calendar year 1915 gathering information on the oil industry, which

was published as Extracts from Bulletin No. 33, together with a paper on the geologic structure of the Canton and Avon quadrangles by T. E. Savage. Mr. Kay also made a short examination of the Bremen anticline in Randolph County and issued a report as Second Extract from Bulletin No. 33. Mr. Nelson and rodman ran detailed levels in the Staunton gas field and the results were embodied in Extract from Bulletin No. 33. In this paper recommendations were made for the extension of the producing area. J. L. Rich, a levelman, and two rodmen were engaged through the field season of 1915 on new surveys of the Birds and Vincennes quadrangles and on the revision of the Hardinville and Sumner quadrangles for publication as geological folios and as State bulletins. T. E. Savage and assistant were engaged practically two months on the same area, more especially on the stratigraphy of the upper beds.

At the close of the fiscal year, Mr. Kay made a hasty trip through the western part of Illinois for the purpose of selecting favorable areas for geologic work. Detailed structural work was begun at the south end of the State. A preliminary report will be issued in September. Because of the insistent demands for information regarding oil and gas in this State, it is the policy of the Survey to make available all reliable information at the earliest possible date. A large number of inquiries regarding areas favorable for oil and gas, have been received and answered both in personal conference and by correspondence. The Survey plans to keep in close touch with operations and to make readily accessible any information that will be of value to the public.

GROUND WATER

Mr. Anderson continued his study of artesian water resources of northeastern Illinois until the end of December. Since that time he has given part time service to the preparation of his report, and it is now ready for editing, prior to publication. The bulletin promises to be of great value to those interested in the water supply of Chicago and vicinity.

CLAY

The results of burning tests on a large number of samples collected in 1913 from the roof and floor of coal mines in the State were submitted in a report by Professor Stull. Some additions are now being made by R. K. Hursh, and the bulletin will be printed during the fall.

EDUCATIONAL BULLETINS

Bulletin No. 26 on the geography and geology of the Galena-Elizabeth area by A. C. Trowbridge, E. W. Shaw, and B. H. Shockel was printed and distributed, and Bulletin No. 27 on the geography of the upper Illinois Valley by C. O. Sauer will be distributed about October 1.

The geography of Illinois by Professors Salisbury and Barrows is in progress. The latter has made considerable headway on a preliminary study of historical and geographic facts.

OVERFLOWED LANDS

A report on reclamation of Spoon River Valley by J. G. Melluish of Bloomington, under contract with the Survey, was sublet by him for completion to the Elliott and Harman Engineering Company of Peoria with the consent of the Director. The report is now in the hands of the printer and will be ready for distribution about September 15. The balance of the old appropriation for work on overflowed land was expended for a survey on the Pecatonica River, in cooperation with the U. S. Geological Survey. The survey was undertaken at the special request of the Rivers and Lakes Commission. It was finished in November and the published sheets were available in April.

MINERAL STATISTICS

The Survey has continued to cooperate with the U. S. Geological Survey in the collection of mineral statistics, and the results for the year 1915 are given on a later page.

BUREAU OF INFORMATION

The Survey maintains a bureau of information for the convenience of inquirers about mineral resources of Illinois. Requests are received in great numbers both from inside and outside the State. When possible, a bulletin containing the desired information is mailed. Frequently, however, it is necessary to make special study and to reply by letter at some length. Many requests for the identification of minerals are received and answered promptly; others for chemical analysis of specimens are, for the most part, necessarily refused. It has been found that the collection of a representative sample of a material and the investigation of its favorable occurrence for development are quite as essential and require expert advice, just as does chemical analysis. As a rule, therefore, unless a representative of the Survey investigates and samples a mineral deposit, an analysis at public expense is not justified, particularly because otherwise Survey funds would be seriously depleted by work which frequently is of no permanent value. Preliminary examinations and opinions as to probable value of minerals are always cheerfully given.

Topographic and Drainage Sections

In accordance with the cooperative agreements the Commission allotted $9,000 for the continuation of cooperative topographic surveys in Illinois, and the United States Geological Survey allotted an equal amount. The Commission also made an additional allotment of $3,000 for a survey

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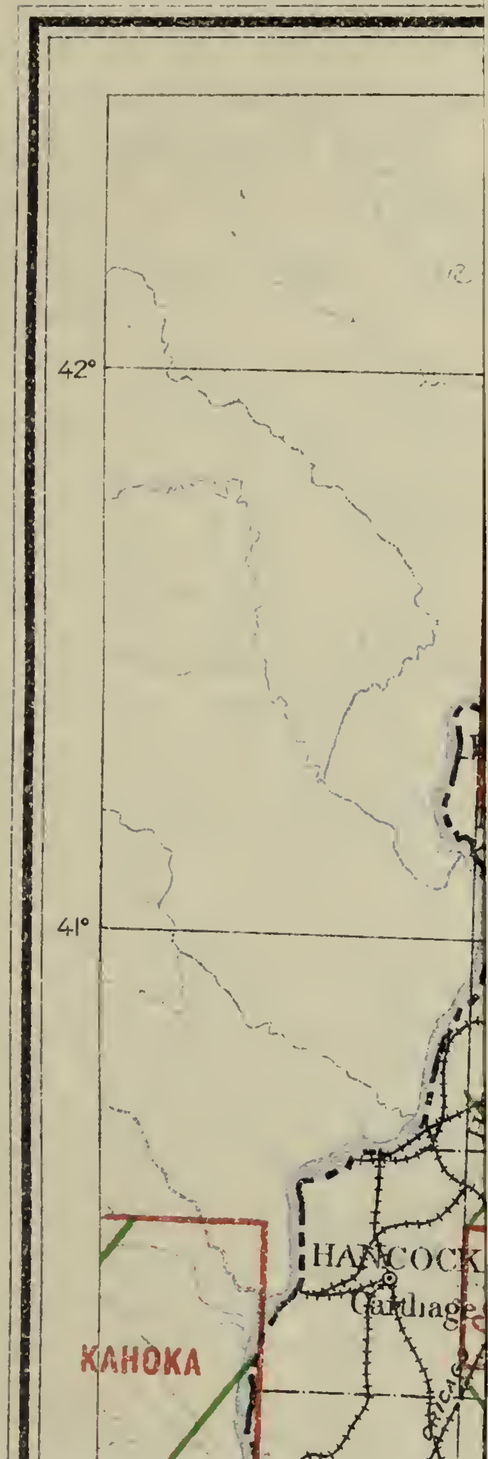
FRANKLIN K. LANE, SECRETAR
U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTC



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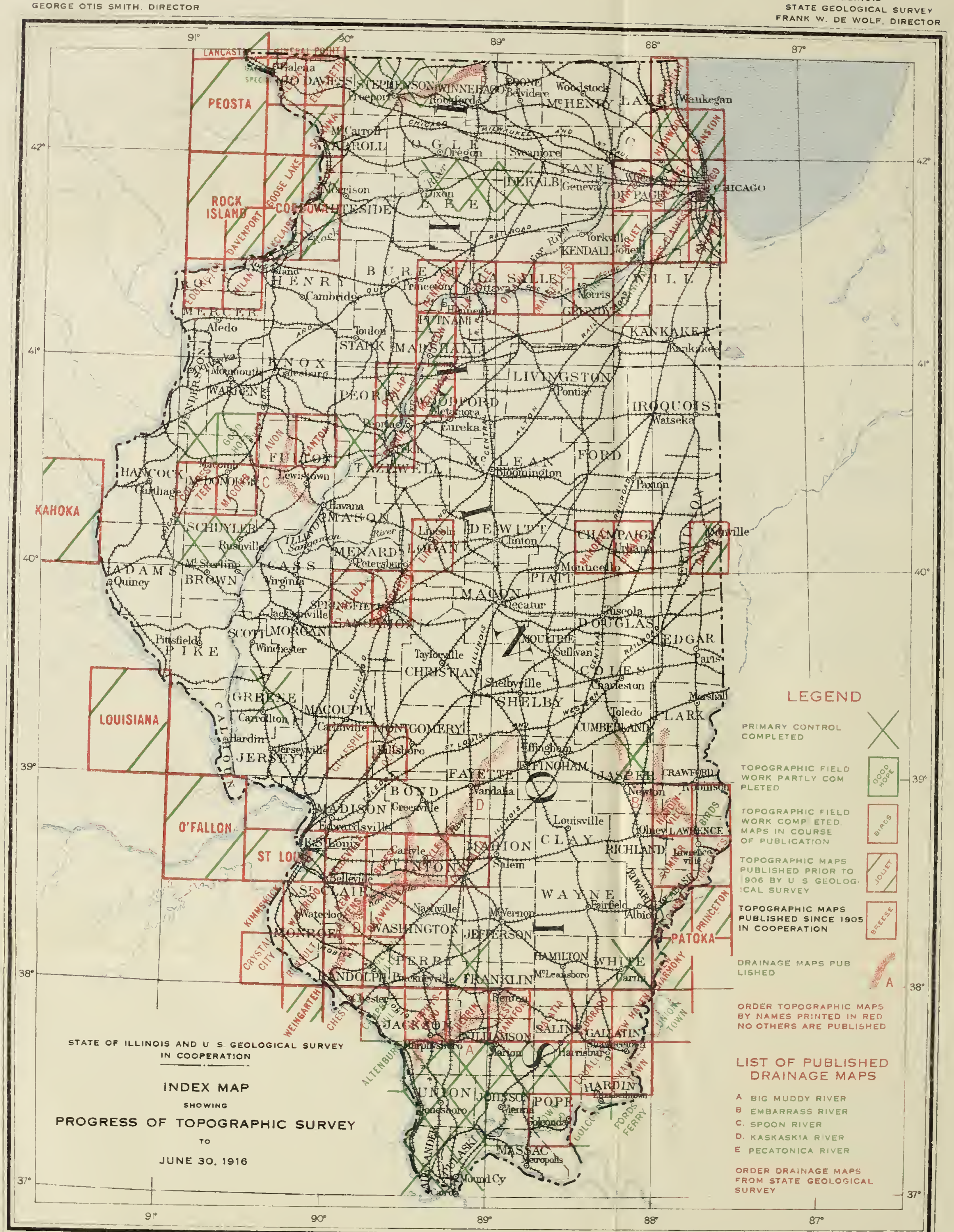
FRANKLIN K. LANE, SECRETARY
U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULL. NO. 33 PLATE I
ILLINOIS
STATE GEOLOGICAL SURVEY
FRANK W. DE WOLF, DIRECTOR



EXTRACT FROM U.S.G.S. BASE MAP

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

of the Pecatonica Drainage Basin, which was met by an allotment of $1,500 by the Federal Survey.

The following is a summary of the field and office work accomplished during the period July 1, 1915, to June 30, 1916, under the general direction of Mr. W. H. Herron, Acting Chief Geographer, and under the immediate supervision of Mr. Glenn S. Smith, Geographer of the Central Division.

The office drafting of the Morris quadrangle map and of the Pecatonica Drainage Basin map was completed. On June 30, 1916, progress in the drafting of topographic maps had been made as follows: Altenberg (Ill.) 9 per cent; Brownfield (Ill.-Ky.) 98 per cent; Campbell Hill (Ill.) 38 per cent.

The adjustment of the levels for the Campbell Hill, Freeport, Morris, Pecatonica, Rockford, Vienna, and Wilmington quadrangles was completed, and the final computation of geographic positions was made for the Belvidere, Campbell Hill, Dongola, Essex, Joliet, Joppa, Marion, Oregon, Pecatonica, Peotone, Rockford, Vienna, and Wilmington quadrangles.

The methods of the Pecatonica survey party are described as follows:

The horizontal control consisted of primary traverse run with transit and steel chain lines about six miles apart, locating all section corners, road crossings, et cetera, along the line and establishing permanent marks at intervals of six miles. This control was then computed and the latitudes and longitudes of all points determined were plotted on planetable sheets covering an area of 7½ minutes each for the use of topographers in the field, polyconic projections being used.

From these localized points, the topographer by means of the telescopic alidade and planetable ran control lines, using stadia measurements, connecting the section corners within the area surrounding the primary traverse, to which were adjusted the land lines by use of the Land Office measurements.

The vertical control was based on mean sea level datum and was run with a 20-inch Y level and New York rod, using steel pin for turning points, the limit of closure being $.05\sqrt{\text{length of circuit in miles}}$ and the length of sights limited to 300 feet. Level lines were run on both sides of the valley, with cross lines about six miles apart, establishing permanent bench marks every three miles and temporary bench marks every mile.

With the control plotted on a planetable sheet, the topographic party, consisting of a topographic engineer, recorder, and two stadia rodmen, equipped with a telescopic alidade and 18 by 24 inch planetable board mounted on a Johnson tripod, with a magnetic compass or solar chart for orientation, proceeds to locate the topographic features by stadia measurements and vertical angles, an average of 100 points being located to the square mile, thus insuring an accurate topographic map.

In the wooded area traverse lines were run at such intervals as would insure the same degree of accuracy as in the open country, and it is safe to say that the elevations shown by the contours on these maps are correct within .4 foot.

The area of the map was extended to show the line of the bluffs and carried up the valleys of the incoming drainage far enough to take care of the backwater of the Pecatonica River.

The methods employed on the Pecatonica River survey are very similar to those used in connection with the Embarrass and Spoon River projects.

TABLE 1.—*Progress of field work by the topographic and drainage sections*

Quadrangles	Counties	Publication scale	Area mapped	Levels		Traverse		
				Primary	Perm. B. M's.	Primary	Perm. marks	Secondary
			Sq. mi.	*Miles*		*Miles*		*Miles*
Brownfield	Johnson, Massac, Pope	1:62500	172	..	..	..	..	793
Altenberg	Jackson	1:62500	22	..	..	..	..	..
Vienna	Johnson, Massac, Pulaski	1:62500	138	89	29	45	3	419
Good Hope	Warren, McDonough	1:62500	152	127	..	..	..	685
Campbell Hill	Jackson, Perry, Randolph	1:62500	155	115	29	13	1	382
Morris	Grundy, Kendall	1:62500	216	..	..	..	..	..
Wilmington	Will, Kankakee	1:62500	205	77	22	39	3	..
Peotone	Will, Kankakee	....	..	..	..	10	1	..
Essex	Will, Kankakee	....	..	..	..	8	1	..
Joliet	Will, Dupage, Cook	....	..	..	..	9	1	..
Dongola	Pulaski, Union, Johnson	....	..	..	..	43	7	..
Joppa	Massac	....	..	..	..	10	1	..
Marion	Johnson, Union	....	..	..	..	9	1	..
Jonesboro	Union	....	..	..	..	12	..	..
Thebes	Alexander, Pulaski	....	..	..	..	11	..	..
Pecatonic Drainage Survey	Stephenson, Winnebago	1:24000	54	136	36	112	9	971
	Totals		1,114	544	116	321	28	3,250

Publications

REPORTS

Specifications for printing and binding Survey reports were submitted for bids in December, and a contract was made with the Pantagraph Printing and Stationery Company of Bloomington, Illinois, with the approval of the Superintendent of Printing. Publications of the year include the following bulletins:

Bulletin 31: Oil investigations in Illinois in 1914.
Bulletin 14: Illinois Coal Mining Investigations: Coal resources of the Danville area.
Bulletin 20: Miscellaneous oil and coal reports and administrative report for 1910 and 1911.
Bulletin 26: Geology and geography of the Galena and Elizabeth quadrangles.

The following Illinois Coal Mining Investigations bulletins are in press:

Bulletin 15: Coal resources of Franklin, Williamson, and Jefferson counties, by G. H. Cady.
Bulletin 3: Chemical studies of Illinois coal, by Professor S. W. Parr.

Other reports awaiting printing are:

Bulletin 27: Geography of the upper Illinois Valley, by Carl O. Sauer.
Bulletin 23: Miscellaneous papers of 1912.
Bulletin 30: Miscellaneous papers of 1913 and 1914.
Bulletin 33: Administrative report and miscellaneous papers for 1915.

The distribution of these reports so as to prevent waste, and yet make them most widely available, has been in itself a considerable task. It is thought that the interests of all concerned would be best met if 500 copies of each report were reserved for sale at the cost of printing, the receipts from the sales being turned into the State treasury. This makes it possible for libraries to complete their sets and for persons having real need for any of the volumes to obtain the earlier ones at small cost. The remainder of the edition is distributed by the Survey and the Secretary of State to institutions and individuals making application for them, or is exchanged with other Surveys or publishing organizations.

Any of the published reports will be sent upon receipt of the amount noted. Money orders, drafts, and checks should be made payable to F. W. DeWolf, Director.

MAPS

A coal mine map of the State is being published on the scale of our large base map. Shipping coal mines are located by symbols, with a number which refers to a printed list of mines and addresses. The map should be ready for distribution in September.

Contracts have been let for topographic maps of Clinton and Monroe counties, and are being considered for Gallatin and Lawrence counties.

In the spring of 1917 similar maps for Randolph and Hardin counties will be ready for engraving. The publication of maps on a county-unit basis seems to be very popular and probably should be kept in mind in the selection of quadrangles for topographic survey from year to year. The work proposed for the coming year will complete McDonough County.

The accompanying illustration (Pl. I) shows the areas for which topographic maps have been prepared in cooperation with the U. S. Geological Survey. Those already published may be obtained from this office by remitting 10 cents for each copy. As the maps do not conform to county lines, those desired should be ordered by quadrangle name.

The topographic maps are distributed also from Washington. They may be purchased at the rate of 10 cents each, when fewer than 50 copies are purchased, but when they are ordered in lots of 50 or more copies, the price is 6 cents each. Drafts or money orders should be sent to the Director, U. S. Geological Survey, Washington, D. C. He is not allowed to receive postage stamps or personal checks in payment.

Expenditures

The total expenditures for the period from July 1, 1915 to June 30, 1916, were as follows:

Table 2.—*Total expenditures July 1, 1915 to June 30, 1916*

General appropriation—		
Balance on hand July 1, 1915	$ 402.09	
Appropriation July 1, 1915	35,805.00	
Total available	....	$36,207.09
Expenditures July 1, 1915 to June 30, 1916—		
Salary and expenses of administration	6,491.03	
Clerical help and general office expenses	4,804.72	
Equipment for new offices	1,153.55	
Postage for distribution of bulletins	451.00	
Oil investigations	1,247.30	
Coal investigations	948.21	
Cooperative geological surveys (quadrangles)	4,093.56	
General stratigraphic studies	602.06	
Water resources investigations	1,127.23	
Clay resources investigations	250.00	
Geological surveys (quadrangles)	30.00	
Structural geology	369.98	
Educational series	309.30	
Statistics	114.90	
Miscellaneous	247.13	
Topographic surveys	6,149.60	28,389.57
Balance available July 1, 1916	....	$ 7,817.52

Special appropriation for survey and study of overflowed lands—		
Balance on hand July 1, 1915	$3,714.61	
Appropriation July 1, 1915	....	
Total available	....	$3,714.61
Expenditures July 1, 1915 to June 30, 1916	....	$3,714.61
Balance available July 1, 1916	....	———
Appropriations for engraving and lithographing maps and illustrations—		
Balance on hand July 1, 1915	$ 120.04	
Appropriation July 1, 1915	2,500.00	
Total available	....	$2,620.04
Expended July 1, 1915 to June 30, 1916	....	492.37
Balance available July 1, 1916	....	$2,127.67
Appropriation for printing and binding—		
Balance on hand July 1, 1915		
Appropriation July 1, 1915	$6,500.00	
Total available	....	$6,500.00
Expended July 1, 1915 to June 30, 1916	....	3,477.20
Balance available July 1, 1916	....	$3,022.80

Recommendations

(november, 1916)

NEEDS OF THE GEOLOGICAL SURVEY

Funds for the Geological Survey Commission have not been increased during the past three bienniums except that $10,000 for printing and binding was transferred to the Commission by the last General Assembly instead of being provided indirectly through the State Board of Contracts as formerly. A relative loss of effective funds has been experienced because of increased cost of all kinds of work, including that intrusted to this Commission. An increase of 8 per cent, or about $3,500 per year, in appropriations is urgent in order to maintain the past rate of various surveys related to development of coal, oil, and other State resources. Real additional increases in funds are needed in certain special lines, as follows:

Topographic mapping.—Topographic mapping to date has included 52 quadrangles lying in 43 different counties and covering 11,700 square miles. Thus 20 per cent of the State has been finished. The usefulness of these surveys in efforts to develop natural resources, drain farm lands, and to build railroads and highways is beyond question. Other states appreciate

such surveys also, and maps have been completed or very nearly completed for Connecticut, Kansas, Maryland, Massachusetts, New Jersey, New York, Ohio, Rhode Island, Utah, and West Virginia. Illinois will not be completely mapped for 40 years if the present rate is continued, but larger appropriations should be made, especially now while the policy of the Federal Government is to allot an amount equal to that provided by the cooperating states. Therefore I strongly recommend that the State appropriate with a view to completing the surveys in 20 years. This requires an additional appropriation of $9,600 per year.

Oil investigations.—Oil production in Illinois has declined 45 per cent since 1908, and the State is now fourth in rank instead of second. However, four new fields of oil or gas have been discovered by Survey work, otherwise the decline in production would be much greater. If rising costs of gasoline and oil are to be checked, it must be by the opening of new fields. I believe that additional fields can be found in Illinois and request increased funds in order that the past successes of the Survey can be repeated in much larger measure. An increased appropriation of $5,000 per year is needed.

Clay investigations.—Development of Illinois clay materials for high-grade products is in its infancy, and progress demands State-wide investigations. Ten years ago an unusual deposit in Union County was investigated and recommended for development on a large scale. Today it is considered equal or superior to clay imported before the war for making crucibles and retort linings. Similarly, a great clay belt in 15 western counties deserves investigation and development. Since clays which may be discovered by the Survey can now be tested in the new building of the Ceramics Department at the University of Illinois, there should be an adequate program of cooperation. The Survey should have an increase of at least $3,500 per annum for this purpose.

Assembling these urgent items of incrase we have a total of $21,600 per annum.

To meet increased costs	$ 3,500
Topographic mapping	9,600
Oil investigations	5,000
Clay investigations	3,500
	$21,600

The chief reason for a substantial increase of the work of the Geological Survey is that the expenditure is not for routine services, but is for scientific investigation looking toward the development of the resources of the State. The practical value of such work has sufficient proof from our own experiences as well as from other states and from foreign countries where industrial development is intense. Increased work will guarantee opportunities for profitable investment of capital and for employment of

our population. It will surely be more economical to utilize our own resources than to ship materials into our markets from other states and countries.

FORM OF APPROPRIATIONS

Great difficulty has been experienced in conducting the work of the Survey under the limitations of the detailed appropriation bill passed by the last General Assembly. Twenty-five distinct items were provided, and thus elasticity to meet changing conditions and needs of a two-year period was quite insufficient.

Unusual competition for geologists exists at present because of commercial openings in many lines, especially in oil investigations. At other times men are more available and at lower salaries. The appropriations should be sufficiently elastic to permit the Geological Commission and the Civil Service Commission to meet changing conditions which are certain to arise and can not be foreseen. In general the interests of the State will be best served by making appropriations in suitable lump sums under a few specified items, such as: Salaries, Supplies, Equipment, and Open-order or Contract Service.

CONSOLIDATION OF STATE BUREAUS

The movement for consolidation of certain State bureaus doubtless deserves support in many instances. I venture to suggest, however, that the administration of the Illinois Geological Survey at the University under a small unpaid Commission is most conducive to successful service, and is essentially the same as the administration of the strongest and most effective surveys of the country. A change in organization should be undertaken only to effect better or more economical service. The recommendations of the Economy and Efficiency Commission to combine the Geological Survey, the Water Survey, and the Natural History Survey would not provide any economy, and in my judgment could not increase the efficiency of the Geological Survey. Whereas this plan for combination is perhaps the least destructive that has been recently proposed, its constructive value may be seriously questioned.

MINERAL RESOURCES IN ILLINOIS IN 1915

By H. J. Skewes

OUTLINE

ILLUSTRATIONS

TABLES

INTRODUCTION

Public Interest in Mineral Resources

Continued investigations in the State are rapidly revealing new sources of wealth until it has reached the front ranks among mineral-producing states, having been preceded only by Pennsylvania and West Virginia in 1915. Inasmuch as Illinois has always had so great a reputation as an agricultural State, comparatively few realize the increasing wealth arising from the growing mineral industries. A comparison of the figures for the total agricultural products in 1915 with the total mineral products for the same year is hardly an average true relationship as the agricultural produce for 1915 was phenomenal, the greatest in the history of the State. The increasing ratio of values of mineral production to agricultural production during the past 10 years (Table 3) will no doubt be an interesting revelation to many. The low ratio for 1915 is only temporary.

Because of the tremendous importance of the mineral products of Illinois, this source of wealth and revenue rightfully demands the attention of its citizens, for the promotion of this phase of activity affects the social and industrial interests of all, as history shows the advancement of civilization depends almost wholly on the development of mineral resources. A

TABLE 3.—*Comparison of values of total mineral production in Illinois with those of total agricultural products, 1905-1915*

Year	Mineral production	Agricultural production	Ratio of values of mineral to agricultural production
			Per cent
1905	$ 68,025,560	$272,794,107	24.9
1906	72,723,572	253,409,404	28.7
1907	93,539,464	280,666,020	33.3
1908	92,765,688	276,614,637	33.5
1909	98,840,729	322,144,944	30.7
1910	98,891,759	297,976,709	33.2
1911	106,275,115	311,525,706	34.1
1912	123,068,867	285,249,557	43.2
1913	131,825,221	288,613,140	45.9
1914	117,145,108	289,781,140	40.4
1915	114,704,587	486,561,355	23.5

state that produces practically all the country's supply of fluorspar for the great steel industries, stands high in its output and value of cement, clay products, coal, pig iron, petroleum, sand and gravel, and tripoli is indeed worthy of special attention.

It is interesting to note the increasing efficiency in the coal mining industry. In the past 10 years the production has increased from a yearly average of 670 tons per employee to 854 tons, due to a better class of mine workers, improved mining conditions, and modern mine equipment—contributions of labor, capital, and science. The ratio per thousand of lives lost in this work is now only 2.38 as compared with 3.4 in 1905. This human aspect must be encouraging to all interested in the welfare of fellow citizens.

Thus to derive the maximum value from our mineral resources the earnest cooperation of the legislative and scientific departments of the State is necessary. It is a governmental duty to the industries to improve conditions and promote efficiency; with the scientific department rests the educational and investigative work that points out to the citizen the most certain investments of his money. Recent examples of this assistance of science to capital has been most striking in the oil industry. In early years it was the custom to put down many test holes in a wild and rambling fashion without any knowledge of the underground conditions. Now the custom is to make careful investigations as to the structure and other factors, based on rock outcrops and a few test holes intelligently placed. In this way the new and profitable oil field of Schuyler, Hancock, and McDonough counties was discovered. In 1915 the favorable structures (Staunton dome and Spanish Needle Creek dome) that had been pointed out and described by members of the State Geological Survey[1] and by Wallace Lee[2] of the

[1] Blatchley, R. S., Oil and gas in Bond, Macoupin, and Montgomery counties: Ill. State Geol. Survey Bull. 28, 1914. Also Kay, F. H., Coal resources of District VII: Ill. Coal Mining Investigations Bull. 11, 1915.

[2] Lee, Wallace, Oil and gas in the Gillespie and Mt. Olive quadrangles: Ill. State Geol. Survey Bull. 31, p. 71, 1915.

TABLE 4.—*Output and value of mineral products in Illinois, 1906-1915*

Product	1906		1907		1908		1909		1910	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Asphalt ....short tons	....	....	....	....	....	....	....	....	....	....
Briquets ....short tons	....	....	....	....	....	....	....	....	....	....
Cement ....barrels	[a]1,858,403	[a]$2,461,494	[a]2,036,093	[a]$2,632,576	[a]3,211,168	[a]$2,707,044	[a]4,241,392	[a]$3,388,667	[a]4,459,450	[a]$4,119,012
Clay products	....	12,634,181	....	13,220,489	....	11,559,114	....	14,344,453	....	15,176,161
Coal ....short tons	41,480,104	44,763,062	51,317,146	54,687,382	47,659,690	49,978,247	50,904,990	53,522,014	45,900,246	52,405,897
Coke ....short tons	268,693	[b]1,205,462	372,697	[b]1,737,464	362,182	[b]1,538,952	1,276,956	[b]5,361,510	1,514,504	[b]6,712,550
Ferro-alloys........long tons	....	....	....	....	....	....	....	....	....	....
Fluorspar ....short tons	28,268	160,623	25,128	141,971	31,727	172,838	41,852	232,251	47,302	277,764
Iron, pig ....long tons	2,156,866	[b]47,128,000	2,457,768	[b]52,229,000	1,691,944	[b]30,135,000	2,467,156	[b]44,211,000	2,675,646	[b]42,917,362
Lead ....short tons	572	65,208	498	52,788	363	30,492	273	23,478	262	23,056
Lime ....short tons	121,546	534,118	124,784	559,305	92,549	393,951	104,260	454,682	113,239	503,581
Mineral paints, zinc and lead pigments..	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
Mineral waters........gallons sold	574,453	77,287	720,400	91,760	685,763	58,904	639,460	49,108	1,117,620	83,148
Natural gas	....	87,211	....	143,577	....	446,077	....	644,401	....	613,642
Petroleum ....barrels	4,397,050	3,274,818	24,281,973	16,432,947	33,685,106	22,648,881	30,898,339	19,788,864	33,143,362	19,669,383
Pyrite ....long tons	....	....	(c)	(c)	(c)	(c)	5,600	17,551	8,541	28,159
Sand and gravel........short tons	2,657,559	1,043,041	4,550,991	1,367,653	6,657,748	1,503,022	9,155,229	1,949,497	8,586,508	1,730,795
Silver ....fine ounces	....	....	2,900	1,900	2,000	1,100	900	500	2,000	1,100
Stone	....	1,961,456	....	3,789,342	....	3,134,770	....	4,261,818	....	3,853,425
Sulphuric acid (60° Baumè)...short tons	....	....	....	....	....	....	....	....	....	....
Tripoli	(c)	(c)	(c)	(c)	(c)	(c)	....	39,262	....	33,390
Zinc ....short tons	282	34,404	1,446	170,628	298	28,012	675	72,900	351	167,508
Miscellaneous	....	2,037,300	....	247,146	....	103,236	....	51,283	....	1,720,002
Total	$72,723,572		$93,539,464		$92,765,688		$98,840,729		$98,891,759	

[a]Exclusive of natural cement, value for which is included under "Miscellaneous".
[b]Value not included in "Total".
[c]Value included under "Miscellaneous".
[d]From zinc smelting.

Product	1911		1912		1913		1914		1915	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Asphalt ....short tons	(c)	(c)	(c)	(c)	(c)	(c)	41,553	$340,862	188,575	$1,041,378
Briquets ....short tons	(b) (c)	(b) (c)	(b) (c)	(b) (c)	....	....	....	....	....	....
Cement ....barrels	[a]4,582,341	[a]$3,583,301	[a]4,602,617	[a]$3,444,085	[a]4,734,540	[a]$4,784,696	[a]5,284,022	[a]4,848,522	[a]5,435,655	[a]4,884,026
Clay products	....	14,333,011	....	15,210,990	....	15,195,874	....	13,318,953	....	14,791,938
Coal ....short tons	53,679,118	59,519,478	59,885,226	70,294,338	61,618,744	70,313,605	57,589,197	64,693,529	58,829,576	64,622,471
Coke ....short tons	1,610,212	[b]6,390,251	1,764,944	[b]8,069,903	1,859,553	[b]8,593,581	1,425,168	[b]5,858,700	1,686,998	[b]7,016,635
Ferro-alloys...................long tons	(b) (c)	(b) (c)	(b) (c)	(b) (c)	(b) (c)	(b) (c)	(b) (c)	(b) (c)	(b) (c)	(b) (c)
Fluorspar ....short tons	68,817	481,635	114,410	756,653	85,854	550,815	73,811	426,063	(c)	(c)
Iron, pig ....long tons	2,036,081	[b]31,152,927	2,806,378	[b]42,828,816	2,892,263	[b]45,796,966	1,793,714	[b]24,382,458	2,455,894	[b]34,207,901
Lead ....short tons	964	86,760	1,282	115,380	959	84,392	717	55,926	954	89,676
Lime ....short tons	92,169	423,762	98,450	394,892	95,977	433,331	87,603	362,727	88,604	352,954
Mineral paints, zinc and lead pigments..	....	....	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
Mineral waters ....gallons sold	1,304,950	82,330	1,143,625	74,445	1,216,442	68,549	1,760,030	81,307	1,559,489	75,290
Natural gas	....	687,726	....	616,467	....	574,015	....	437,275	....	350,371
Petroleum ....barrels	31,317,038	19,734,339	28,601,308	24,332,605	23,893,899	30,971,910	21,919,749	25,426,179	19,041,695	18,655,850
Pyrite ....long tons	17,441	47,020	27,008	62,980	11,246	31,966	22,538	59,079	14,849	22,476
Sand and gravel..............short tons	8,488,683	1,990,922	6,957,901	1,929,822	7,992,140	2,070,491	7,696,130	1,859,519	7,708,012	1,984,569
Silver ....fine ounces	3,036	1,609	4,731	2,909	3,541	2,139	2,112	1,168	3,864	1,959
Stone	....	3,467,930	....	3,841,504	....	4,140,953	....	2,934,078	....	2,907,410
Sulphuric acid [d](60° Baumé)..short tons	144,805	958,591	160,378	1,064,564	195,145	1,303,986	243,457	1,551,876	....	2,036,311
Tripoli	....	45,910	....	27,339	....	128,892	....	59,394	....	502,937
Zinc ....short tons	4,219	480,966	4,065	560,970	2,236	250,432	4,811	490,722	5,534	1,372,432
Miscellaneons	....	1,199,475	....	1,992,632	....	1,756,126	....	1,272,055	....	2,261,215
Total	$106,275,115		$123,068,867		$131,825,221		$117,145,108		$114,704,587	

[a]Exclusive of natural cement, value for which is included under "Miscellaneous".
[b]Value not included in "Total".
[c]Value included under "Miscellaneous".
[d]From zinc smelting.

U. S. Geological Survey working in cooperation with the State, were tested and found to comply with all expectations. This method of systematic and intelligent procedure increases financial efficiency and makes for the advancement of society and industry.

Scope and Purpose of Report

It is the purpose of this report to present not only bare statistical figures for each mineral product, but to make new interpretations, to discuss changing conditions and their causes, to present comparisons of figures, and to show the rank of the different counties of the State and of Illinois amongst other states in those products in which she has attained a prominent place. A little geology has also been presented where it has an interesting relationship to statistics. It is hoped that the bibliography at the end of the paper may be of considerable assistance to many, as the Survey receives many requests for sources of information regarding the various mineral industries.

Acknowledgments

The mineral statistics for Illinois in 1915 were collected by the U. S. Geological Survey and the Illinois State Geological Survey in cooperation. Many of the figures used in this report are the result of compilations by the Federal Survey, as published in the series of Annual Reports and of the Mineral Resources of the United States. Acknowledgments are due also to individual members of the Survey who willingly rendered considerable assistance.

Review of Mineral Resources

The value of the total mineral production in Illinois for 1915, exclusive of pig iron and coke, was $114,704,587, which ranked it third among the states, having been exceeded by Pennsylvania and West Virginia. A comparison of Illinois values in 1914 and 1915 shows a decrease of 2.08 per cent in total value of output. Almost two-thirds of the decrease in the petroleum production was made up by the marked increase in output of other products. Table 4 shows the value of Illinois products from 1906 to 1915. In order of values for 1914, the products derived strictly from Illinois are coal, petroleum, clay products, cement, stone, sulphuric acid, zinc, asphalt, fluorspar, tripoli, lime, natural gas, mineral paints, lead, mineral waters, pyrite, and silver. Pig iron, coke, and ferro-alloys were manufactured in Illinois from imported raw materials.

Of the 102 counties only three made no report of mineral production in 1915—Calhoun, Clay, and Piatt. Exact figures can not be given in Table 5 for total mineral output of every county, as the production of petroleum and natural gas is not kept by counties by the large producing companies in the main oil field, but a fair approximation has been reached.

The county of highest value of mineral output was Lawrence, which exceeded ten million dollars in petroleum, natural gas, and clay products. Franklin County produced coal valued at $8,813,376. Cook County was valued at $7,719,486 in clay products, stone, sand and gravel, lime, and cement, named in decreasing order of importance; Williamson, at $7,572,-132 in coal and clay products; and La Salle at $7,437,624 in cement, coal, clay products, sand and gravel, quartz, clay, mineral water, and stone. Crawford County, with petroleum, natural gas, and stone, and Sangamon County, with coal, clay products, and sand and gravel, each exceeded the five million dollar mark. Each of 26 counties exceeded one million dollars in total output; besides the 7 already mentioned these are Bureau, Christian, Clark, Clinton, Crawford, Fulton, Jackson, Jo Daviess, Lee, Macoupin, Madison, Marion, Montgomery, Peoria, Perry, St. Clair, Saline, Vermilion, and Will.

The counties showing the greatest variety of mineral products were La Salle, already discussed, and Madison, which reported coal, clay products, stone, sand and gravel, lime, mineral water, pyrite, and petroleum, totaling $3,794,216.

Table 5 presents a summary of statistics by counties for 1915.

TABLE 5.—*Products and total mineral values, by counties, 1915*

County	Products (named in decreasing order of importance)	Total value
Adams	Lime, stone, clay products	$ 221,467
Alexander	Tripoli, stone, sand and gravel	142,913
Bond	Coal, sand and gravel, natural gas	59,813
Boone	Clay products, stone, sand and gravel	18,528
Brown	Mineral water, clay products	450
Bureau	Coal, clay products, sand and gravel, natural gas	2,164,727
Calhoun	....	....
Carroll	Sand and gravel, stone	4,478
Cass	Clay products, sand and gravel	10,022
Champaign	Clay products, natural gas	42,633
Christian	Coal, clay products	2,312,234
Clark	Petroleum, natural gas, stone	[a]1,428,216
Clay	....	....
Clinton	Coal, clay products	[a]1,352,757
Coles	Petroleum	[a]25,600
Cook	Clay products, stone, sand and gravel, lime, cement	7,719,486
Crawford	Petroleum, natural gas, stone	[a]5,600,737
Cumberland	Petroleum, natural gas, mineral water	[a]464,878
Dekalb	Sand and gravel, clay products	952
Dewitt	Natural gas, clay products	2,026
Douglas	Clay products	(b)
Dupage	Stone, clay products, sand and gravel	114,189
Edgar	Clay products, petroleum, natural gas	14,087
Edwards	Clay products	144,703
Effingham	Clay products	(b)
Fayette	Clay products, sand and gravel	40,475
Ford	Clay products	1,500
Franklin	Coal	8,813,376
Fulton	Coal, clay products, sand and gravel	2,301,505
Gallatin	Coal, clay products	73,700
Greene	Clay products, coal, clay	303,268

Table 5.—*Products and total mineral values, by counties, 1915*—Continued

County	Products (named in decreasing order of importance)	Total value
Grundy	Coal, clay products, clay	$ 483,581
Hamilton	Clay products	(b)
Hancock	Clay products, coal, stone	36,653
Hardin	Fluorspar, lead, silver, stone	670,745
Henderson	Sand and gravel	9,800
Henry	Coal, clay products, mineral water	98,373
Iroquois	Clay products	35,014
Jackson	Coal, clay products	1,058,993
Jasper	Petroleum	2,265
Jefferson	Coal	(b)
Jersey	Clay products, stone	81,406
Jo Daviess	Zinc, lead, stone, sand and gravel	1,422,818
Johnson	Stone	(b)
Kane	Sand and gravel, clay products, stone, mineral water	315,903
Kankakee	Clay products, stone, lime	715,072
Kendall	Sand and gravel	(b)
Knox	Clay products, coal	941,690
Lake	Clay products, sand and gravel, mineral water	483,539
La Salle	Cement, coal, clay products, sand and gravel, quartz, clay, mineral water, stone	7,437,624
Lawrence	Petroleum, natural gas, clay products	[a]10,512,983
Lee	Cement, clay products, stone, sand and gravel, natural gas	1,200,100
Livingston	Clay products, coal	884,775
Logan	Coal, sand and gravel, clay products	482,174
McDonough	Clay products, petroleum, clay, coal	[a]862,192
McHenry	Clay products, sand and gravel, mineral water	377,288
McLean	Coal, clay products, natural gas	192,770
Macon	Coal, clay products	405,387
Macoupin	Coal	[a]4,653,018
Madison	Coal, clay products, stone, sand and gravel, lime, mineral water, pyrite, petroleum	3,794,216
Marion	Coal, petroleum, clay products	[a]1,357,113
Marshall	Coal	768,009
Mason	Clay products	(b)
Massac	Clay products	(b)
Menard	Coal, clay products, sand and gravel	112,080
Mercer	Coal, clay products, sand and gravel	751,130
Monroe	Stone, sand and gravel, clay products	19,674
Montgomery	Coal, clay products	3,011,806
Morgan	Mineral water, clay products, coal, petroleum, natural gas	49,131
Moultrie	Coal, clay products	201,576
Ogle	Sand and gravel, clay products, clay	76,154
Peoria	Coal, sand and gravel, clay products, mineral water	1,575,548
Perry	Coal	2,357,064
Piatt	....	....
Pike	Stone, clay products, natural gas, lime	34,885
Pope	Mineral water	(b)
Pulaski	Clay products	(b)
Putnam	Coal	922,191
Randolph	Coal, stone, clay products	933,215
Richland	Clay products	(b)
Rock Island	Clay products, sand and gravel, coal, stone, mineral water	164,199
Saline	Coal, clay products	4,439,401
Sangamon	Coal, clay products, sand and gravel	5,479,461
Schuyler	Coal, clay products	13,168
Scott	Clay products, clay, coal	39,211
Shelby	Coal, clay products	134,028
St. Clair	Coal, stone, clay products, sand and gravel	3,022,740
Stark	Coal, clay products	25,580
Stephenson	Stone	7,999
Tazewell	Coal, clay products, sand and gravel, mineral water	557,810

Union	Tripoli, stone, clay	$ 494,125
Vermilion	Coal, clay products, stone, pyrite	3,898,562
Wabash	Petroleum, sand and gravel	[a]61,757
Warren	Clay products, coal	354,839
Washington	Coal, clay products	456,343
Wayne	Clay products	(b)
White	Coal, clay products, lime, sand and gravel	61,329
Will	Clay products, stone, coal, sand and gravel, mineral water	1,022,760
Whiteside	Sand and gravel	36,977
Williamson	Coal, clay products	7,572,132
Winnebago	Sand and gravel, stone, lime	419,544
Woodford	Coal, clay products, mineral water	317,419

[a]The figures for natural gas and petroleum for certain counties have been estimated, since the Ohio Oil Co. has no way of dividing its total figures for each of its districts into county units. A fair approximation of the values for petroleum has been reached for Clark, Clinton, Coles, Crawford, Cumberland, Lawrence, Marion, McDonough, and Wabash counties by first dividing the total for the State into the proportion of the daily output by districts; the districts were then subdivided into counties according to the proportion of the number of wells in each county. The approximation of the natural gas for Clark, Crawford, Cumberland, Lawrence, and Macoupin counties was made by dividing the totals for two different large companies into the proportion of the number of wells in each county.

[b]Concealed, fewer than 3 producers.

COAL

In 1915 the value of the output of coal in Illinois comprised 12.8 per cent of the total value of the bituminous coal production for the country, and 56.3 per cent of the total value of the mineral production of the State. The output of the 443 mines for this year was 58,829,576 short tons valued at $64,622,471 as compared with 519 mines producing 57,589,197 short tons valued at $64,693,529 in 1914. Because of the boom in the manufacturing industries, the coal mining business began to improve in 1915.

In quantity of production Illinois ranked third in 1915, a position it has held since 1909, when it yielded its second place to West Virginia. The total production of coal in Illinois from 1833, when its mining became a commercial industry, to 1915 was 1,081,935,096 short tons, a figure which gives the State second rank. The total for Pennsylvania was 3,037,983,490; for West Virginia, 936,380,719 short tons.

The average price for coal at the mines from 1905 to 1915 is given in Table 6.

Table 6.—*Average price per short ton of Illinois coal at mines, 1905-1915*

1905	$1.06
1906	1.08
1907	1.07
1908	1.05
1909	1.05
1910	1.14
1911	1.11

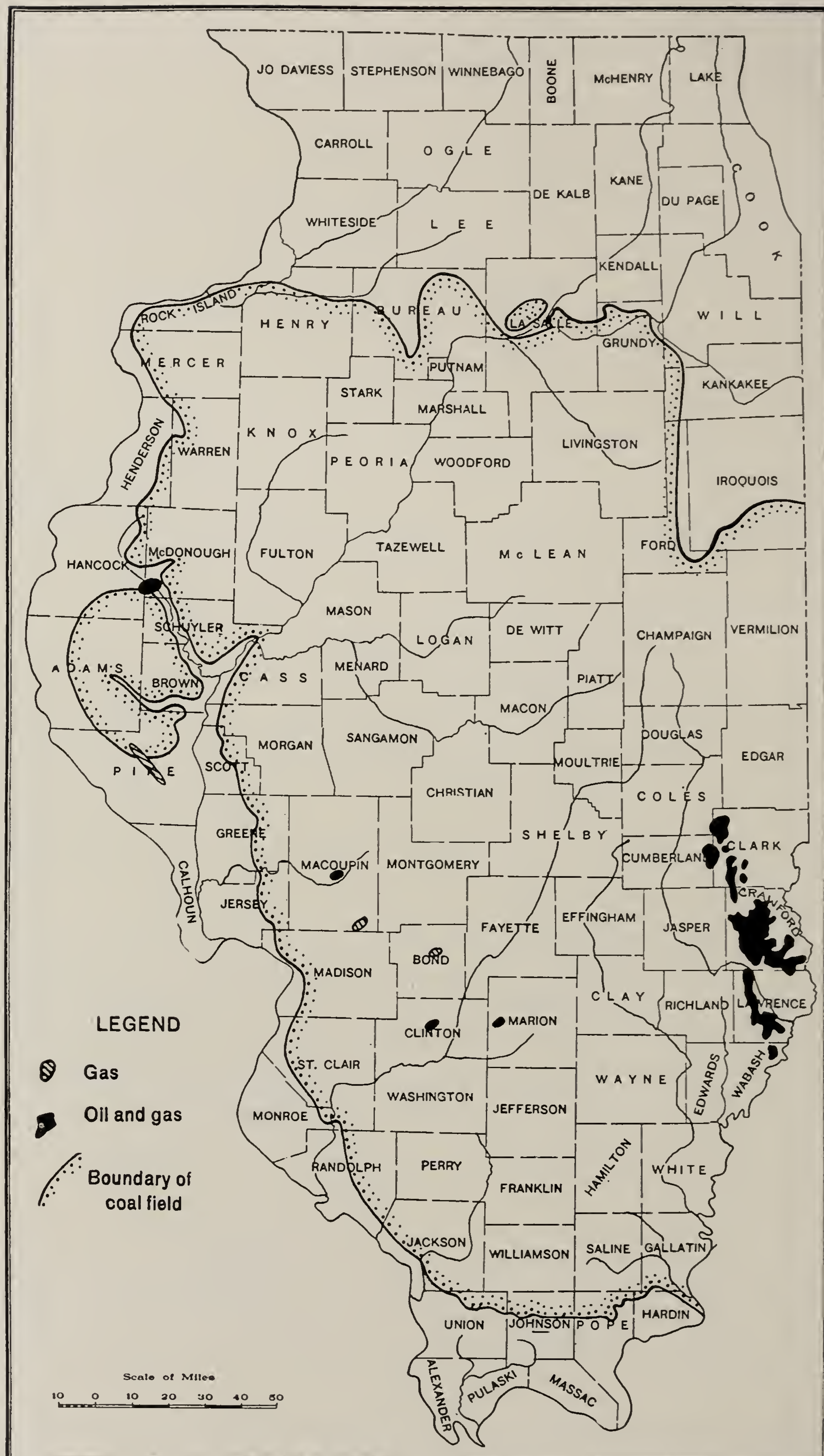


Fig. 1.—Map showing coal and oil fields of Illinois in 1915.

1912	1.17
1913	1.14
1914	1.12
1915	1.09

Of the 102 counties in the State, 49 within the area of the coal field (Fig. 1) reported a production of coal in 1915. For the last two years Franklin County has enjoyed the distinction of first rank, the output in

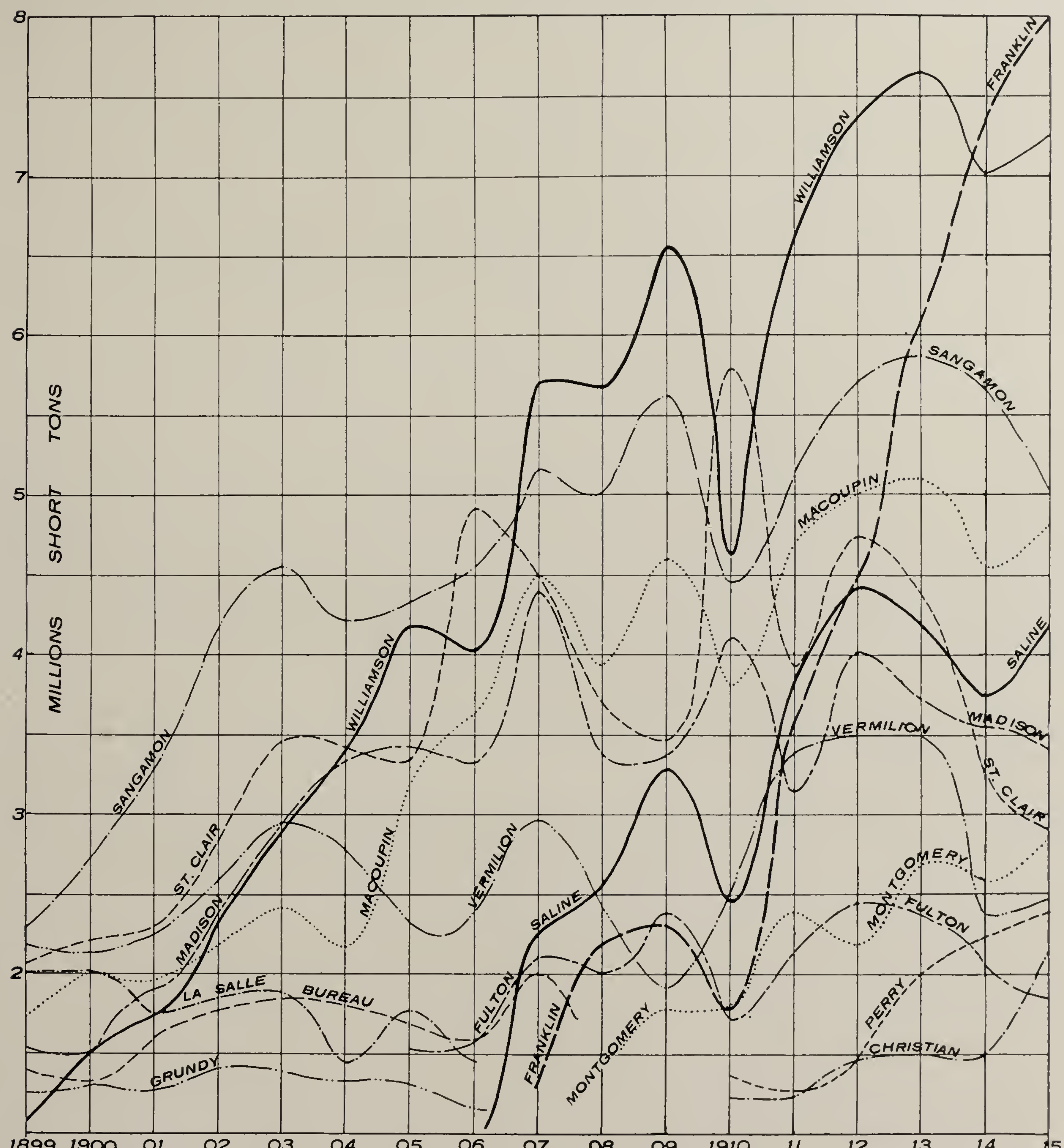


FIG. 2.—Diagram showing production of coal in the leading counties of Illinois, 1899-1915.

1915 having been 8,027,773 short tons. The rapid rise of this county since the opening up of its first shaft mine at Zeigler in the spring of 1903 is illustrated graphically in figure 2. Prior to 1903—1890, 1891, 1892 and

Table 7.—*Production of coal in Illinois, by counties, in short tons, 1905-1915*

County	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Bond	126,231	132,325	138,990	60,129	89,861	139,398	119,250	232,571	223,786	123,730	27,659
Bureau	1,701,255	1,580,085	2,010,762	1,512,971	1,612,452	973,346	1,628,688	1,677,317	1,639,208	1,284,311	1,202,698
Calhoun	4,727	5,045	2,850	3,521	----------	----------	1,400	1,156	----------	----------	----------
Christian	879,360	934,452	1,368,159	1,377,166	1,395,158	1,223,295	1,222,259	1,467,846	1,504,716	1,486,053	2,135,052
Clinton	579,281	515,796	1,302,391	1,078,848	970,709	950,243	921,225	1,040,479	1,049,575	1,090,787	1,315,648
Franklin	----------	----------	1,306,966	2,187,383	2,316,509	1,778,768	3,555,586	4,442,284	6,072,102	7,311,209	8,027,773
Fulton	1,529,249	1,579,224	2,113,643	2,012,415	2,388,617	1,721,527	2,133,029	2,453,424	2,388,775	2,052,170	1,849,906
Gallatin	82,682	92,731	78,055	59,667	64,713	70,091	63,008	64,244	46,105	81,735	77,380
Greene	4,435	2,206	2,310	9,506	7,318	9,082	6,207	7,841	5,009	6,665	5,764
Grundy	1,310,892	1,162,019	1,327,321	1,081,442	1,114,101	600,281	776,800	540,787	401,527	388,368	293,660
Hamilton	----------	----------	----------	(c)	----------	----------	----------	----------	----------	----------	----------
Hancock	3,300	4,498	2,034	1,406	1,085	640	230	----------	----------	1,678	1,285
Henry	146,995	149,188	149,721	141,624	137,060	124,243	90,722	58,613	43,383	47,010	46,219
Jackson	818,841	646,196	645,333	624,055	652,280	584,240	687,753	703,190	723,863	601,697	682,042
Jefferson	25,925	7,600	12,000	18,675	4,800	10,000	9,500	21,032	35,000	9,051	8,900
Jersey	----------	1,397	1,162	1,496	1,000	----------	----------	----------	----------	----------	----------
Kankakee	700	39,499	26,704	30,994	25,000	----------	----------	----------	----------	----------	----------
Knox	58,972	51,654	40,996	41,040	21,973	28,295	30,136	22,293	18,280	14,150	11,985
La Salle	1,772,988	1,467,672	1,677,990	1,557,173	1,686,391	1,178,885	1,610,470	1,537,591	1,564,459	1,279,592	1,192,791
Livingston	284,984	273,831	303,497	265,666	246,031	162,898	89,423	65,774	63,877	64,461	63,341
Logan	445,546	435,559	477,115	372,980	395,888	409,244	334,860	466,528	351,666	352,181	311,346
McDonough	19,496	43,774	32,199	17,818	16,276	26,338	8,027	14,446	12,603	5,251	5,132
McLean	159,921	145,000	151,146	95,854	116,412	83,982	96,517	89,781	88,777	79,008	80,321
Macon	231,235	292,884	269,766	235,237	238,607	235,361	236,203	291,590	206,140	217,217	162,550
Macoupin	3,177,484	3,637,827	4,507,270	3,894,199	4,597,775	3,854,229	4,688,212	4,986,574	5,097,619	4,555,834	4,832,540
Madison	3,434,399	3,324,857	3,927,721	3,367,820	3,373,798	4,102,773	3,152,705	4,025,878	3,732,153	3,546,256	3,419,955
Marion	1,009,759	1,012,866	1,185,533	981,284	1,171,950	812,873	1,224,326	1,311,024	988,964	906,837	925,365
Marshall	499,672	418,904	482,796	393,281	295,812	267,447	423,984	449,660	426,490	383,331	408,566
Menard	415,266	429,971	389,918	355,309	303,948	332,557	190,477	177,578	120,174	76,603	78,893
Mercer	532,854	412,165	453,621	376,435	369,762	229,024	297,552	393,018	408,875	372,528	340,840
Montgomery	598,064	720,415	1,289,021	1,410,978	1,780,668	1,799,720	2,395,814	2,182,823	2,689,702	2,597,677	2,877,459
Morgan	4,565	9,100	5,513	3,244	1,200	1,300	1,268	1,000	1,222	906	300

County	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Peoria	897,946	914,863	1,103,312	921,929	914,961	810,595	1,037,362	1,225,574	1,163,073	1,055,323	1,193,351
Perry	1,298,572	1,509,716	1,784,469	1,576,891	1,423,135	1,367,771	1,272,292	1,444,114	2,013,128	2,236,480	2,383,658
Putnam	----------	156,928	362,858	466,019	597,703	364,882	772,976	720,048	724,170	605,863	636,776
Randolph	440,991	634,270	824,761	751,605	799,893	1,025,557	777,746	798,163	763,472	956,582	892,948
Rock Island	68,383	62,321	52,938	50,781	46,228	66,207	65,983	66,817	35,672	36,022	24,747
St. Clair	3,329,914	4,904,811	4,511,879	3,696,017	3,471,630	5,788,567	3,931,479	4,734,840	4,383,459	3,246,322	2,908,129
Saline	675,701	980,864	2,247,842	2,552,137	3,283,939	2,459,650	3,820,410	4,417,874	4,189,003	3,746,656	4,166,249
Sangamon	4,324,263	4,543,849	5,160,042	5,015,608	5,616,357	4,449,634	5,137,835	5,714,742	5,875,853	5,679,595	5,075,823
Schuyler	2,880	3,090	7,553	15,269	4,573	2,427	6,138	4,573	1,855	2,781	5,864
Scott	13,423	12,437	17,639	3,427	2,056	2,400	464	460	600	1,000	1,000
Shelby	104,216	138,257	155,930	181,373	124,087	135,672	81,615	185,501	193,632	196,339	88,672
Stark	22,725	17,661	25,897	20,351	23,159	32,582	37,293	34,176	14,610	12,703	11,919
Tazewell	231,373	189,882	235,971	206,882	208,049	155,659	220,783	271,321	341,626	335,566	263,247
Vermilion	2,342,238	2,389,285	2,973,253	2,452,485	1,919,955	2,515,250	3,385,200	3,434,923	3,501,880	2,394,081	2,469,263
Warren	10,354	9,520	9,139	11,687	12,304	10,275	9,044	5,021	3,383	1,510	1,339
Washington	87,913	85,812	29,000	72,500	31,322	22,500	25,000	244,879	319,370	497,000	445,028
White	----------	8,000	16,453	19,583	22,133	23,722	35,681	27,052	22,304	32,111	32,118
Will	137,957	154,955	183,985	162,239	162,307	124,652	178,397	130,806	149,926	136,758	141,416
Williamson	4,167,952	4,417,987	5,697,944	5,670,474	6,537,654	4,620,372	6,614,029	7,354,507	7,644,397	7,066,029	7,264,395
Woodford	[a]348,707	[a]717,566	[b]158,742	[d]174,031	194,410	125,823	164,001	185,499	[g]302,184	[g]315,840	[g]337,514
Small mines	69,777	69,299	75,036	68,786	[e]111,981	85,969	109,759	157,994	71,097	98,340	100,747
Total	38,434,363	41,480,104	51,317,146	47,659,690	50,904,990	45,900,246	53,679,118	59,885,226	61,618,744	57,589,197	58,829,576
Total value	$40,577,592	$44,763,062	$54,687,382	$49,978,247	$53,522,014	$52,405,897	$59,519,478	$70,294,338	$70,313,605	$64,693,529	$64,622,471

[a]Includes production of Franklin County.
[b]Includes production of Wabash County.
[c]Included with production of Hancock County.
[d]Includes production of Edgar and Moultrie counties.
[e]Includes production of Crawford and Moultrie counties.
[f]Includes production of Johnson County.
[g]Includes production of Moultrie County.

TABLE 8.—*Production of coal in Illinois, by counties, in short tons, in 1915*

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mine for steam and heat	Total quantity	Total value	Average value per ton	Average number of days active	Average number of employees
Bureau	1,119,424	34,862	48,412	1,202,698	$ 1,961,127	$ 1.63	186	3,084
Christian	2,010,396	81,600	43,056	2,135,052	2,297,686	1.08	181	2,699
Clinton	1,257,928	14,986	42,734	1,315,648	1,239,047	.94	202	1,268
Franklin	7,767,990	52,272	207,511	8,027,773	8,813,376	1.10	171	9,054
Fulton	1,749,714	48,219	51,973	1,849,906	2,267,157	1.23	174	3,143
Gallatin	62,025	10,371	4,984	77,380	62,700	.81	124	159
Greene	--------	5,748	16	5,764	11,300	1.96	181	20
Grundy	267,581	9,154	16,925	293,660	428,414	1.46	175	752
Henry	--------	43,839	2,380	46,219	90,373	1.96	221	100
Jackson	635,519	17,070	29,453	682,042	919,382	1.35	191	733
Knox	--------	11,535	450	11,985	22,287	1.86	179	35
La Salle	720,221	418,306	54,267	1,192,794	2,101,188	1.76	197	2,254
Livingston	8,928	53,913	500	63,341	110,367	1.74	196	90
Logan	237,458	53,501	20,387	311,346	407,070	1.31	160	652
McDonough	500	4,382	250	5,132	11,223	2.19	158	22
Macoupin	4,663,147	48,940	120,453	4,832,540	4,638,945	.96	168	5,311
Madison	3,251,828	95,825	72,302	3,419,955	3,355,763	.98	165	3,730
Marion	890,098	9,385	25,882	925,365	879,840	.95	196	1,139
Menard	51,478	25,753	1,662	78,893	100,455	1.27	112	232
Mercer	318,481	8,468	13,891	340,840	495,732	1.45	207	509
Montgomery	2,814,907	19,922	42,630	2,877,459	2,952,009	1.03	191	3,051
Peoria	1,087,864	85,340	20,147	1,193,351	1,472,948	1.23	196	1,534
Perry	2,302,398	36,191	45,069	2,383,658	2,357,064	.99	205	2,613
Randolph	846,817	28,277	17,854	892,948	886,844	.99	182	1,122
Rock Island	--------	24,041	706	24,747	43,510	1.76	130	68
St. Clair	2,635,062	165,320	107,747	2,908,129	2,597,864	.89	136	3,864
Saline	4,063,483	31,485	71,281	4,166,249	4,414,601	1.06	179	5,004
Sangamon	4,676,786	285,375	113,662	5,075,823	5,290,177	1.04	175	6,563
Schuyler	--------	5,864	-------	5,864	7,918	1.35	213	17
Shelby	70,834	12,693	5,145	88,672	126,458	1.43	89	302
Stark	40	11,679	200	11,919	23,772	1.99	205	33
Tazewell	202,061	56,734	4,452	263,247	330,363	1.25	180	454
Vermilion	2,261,238	152,569	55,456	2,469,263	2,754,147	1.12	198	2,826
Will	116,283	18,233	6,900	141,416	243,757	1.72	197	359
Williamson	7,030,068	44,116	190,211	7,264,395	7,550,097	1.04	182	8,664
Other counties[a] and small mines	1,705,836	444,146	94,081	2,243,803	3,356,910	--------	--------	4,150
Total	54,826,393	2,470,114	1,533,069	58,829,576	$64,622,471	$ 1.10	179	75,610

[a]Bond, Hancock, Jefferson, McLean, Macon, Marshall, Morgan, Moultrie, Putnam, Scott, Warren, Washington, White, and Woodford counties.

1893—about 1,200 tons were mined probably at the outcrop of an 18-inch bed five miles east of West Frankfort on a hill in sec. 23, T. 7 S., R. 2 E. Williamson County held second rank with a production of 7,264,395 short tons. This county led the coal-producing counties of Illinois in quantity of output from 1907 to 1913, inclusive, with the exception of 1910 when it was relegated to second rank by St. Clair County. The rapid rise of Williamson County from fifteenth in 1896 to first rank in 1907 is interesting, and its progress is graphically shown from 1899 to the present date in figure 2. The area underlain by coal in these two counties is about

617 square miles, and in 1915 it produced 26 per cent of the State total. Sangamon County, which in 1915 ranked third with a production of 5,075,823 short tons, has stood high in the list of coal-producing counties for a long time, due probably to the early railroad facilities in that district and to the nearness of the coal to the surface, a condition that encouraged mining in early days. Several interesting facts in the production in several of the leading counties are graphically illustrated in figure 2.

Table 7 presents production by counties from 1905 to 1915, and Table 8 gives the detailed statistics by counties in 1915.

COKE

A comparison of coke production with other states shows that Illinois still retains fourth rank which was reached in 1914 because of the decline in West Virginia's production. The states of preceding rank were Pennsylvania, Alabama, and Indiana.

All the coke made in this State was from four establishments located at South Chicago, Waukegan, and Joliet (2). The coal used for its manufacture was from Pennsylvania and West Virginia. The West Virginia coal is mixed with Illinois coal in the proportion of 4 to 1 and ground fine, a mixture which yields approximately 75 per cent of very satisfactory coke.

The figures for the manufacture of coke in Illinois from 1905 to 1915 are shown in Table 9.

Table 9.—*Statistics of the manufacture of coke in Illinois, 1905-1915*

Year	Establishments	Ovens		Coal used	Yield of coal in coke	Coke produced	Total value of coke at ovens	Value of coke at ovens per ton
		Built	Building					
				Short tons	*Per cent*	*Short tons*		
1905	5	275	----	16,821	61.3	10,307	$ 27,681	$2.69
1906	4	309	----	362,163	74.2	268,693	1,205,462	4.48
1907	5	309	280	514,983	72.3	372,697	1,737,464	4.66
1908	6	430	140	503,359	72.0	362,182	1,538,952	4.25
1909	5	468	40	1,682,122	75.9	1,276,956	5,361,510	4.20
1910	5	508	----	1,972,955	76.8	1,514,504	6,712,550	4.43
1911	4	506	48	2,087,870	77.1	1,610,212	6,390,251	3.97
1912	6	594	40	2,316,307	76.2	1,764,944	8,069,903	4.57
1913	4	568	58	2,481,198	74.9	1,859,553	8,593,581	4.62
1914	4	[a]586	[b]40	1,932,132	73.8	1,425,168	5,858,700	4.11
1915	4	[c]626	----	2,335,933	72.2	1,686,998	7,016,635	4.16

[a]Includes 253 Semet-Solvay, 315 Koppers, and 18 Wilputte ovens.

[b]Semet-Solvay ovens.

[c]Includes 293 Semet-Solvay, 315 Koppers, and 18 Wilputte ovens.

PIG IRON

In accordance with the increasing demand for iron in this country during 1915, Illinois showed an increase in the production of pig iron amounting to 36 per cent, and in value 40 per cent, as compared with the preceding year when the output was unusually low. Table 10 shows the yearly production of pig iron for the last ten years. The rank of third among the states was maintained, Illinois having been preceded by Pennsylvania and Ohio. The manufacture of this product in Illinois is from ore shipped into Chicago and vicinity from Michigan, Wisconsin, and Minnesota.

TABLE 10.—*Production in long tons and value of pig iron in Illinois, 1906-1915*

Year	Quantity	Value	Average price per ton	Year	Quantity	Value	Average price per ton
1906	2,156,866	....	....	1911	2,036,081	$31,152,927	$15.30
1907	2,457,768	$52,229,000	$21.25	1912	2,806,378	42,828,816	15.26
1908	1,691,944	30,135,000	17.81	1913	2,892,263	45,796,966	15.83
1909	2,467,156	44,211,000	17.92	1914	1,793,714	24,382,458	13.59
1910	2,675,646	42,917,362	15.91	1915	2,455,894	34,207,901	13.93

PETROLEUM

The decline in production of petroleum in Illinois that began in 1910 (see Table 11) continued through 1915 when the State was relegated from third to fourth rank by Texas, where new prolific fields were discovered (Fig. 3). Unless there is an increased development of new territory in 1916, Illinois will be forced to fifth rank by Louisiana. In value of total output, however, Illinois still retains third position because of the higher quality of its oil. In 1915 this State produced 6.6 per cent of the total for the country. The distribution of the oil and gas fields of Illinois is shown in figure 1.

The abnormal decline of 13 per cent in quantity from 1914 to 1915 was due largely to the absence of any incentive in the oil market for activity in testing new territory until the latter part of the year when prices rapidly rose; this was too late to affect the statistics for 1915. The discouraging market conditions were caused by the overproduction in Oklahoma, Texas, and Louisiana fields the previous year. Only 757 wells were completed in 1915 as compared with 1,579 in 1914 and 1,721 in 1913.

Of the 13 counties reporting a production of petroleum, Lawrence County led the list as usual and supplied approximately half the total for the State; Crawford County stood second.

The most notable event was the discovery of the new oil and gas field northwest of Staunton following descriptions of the favorable structure

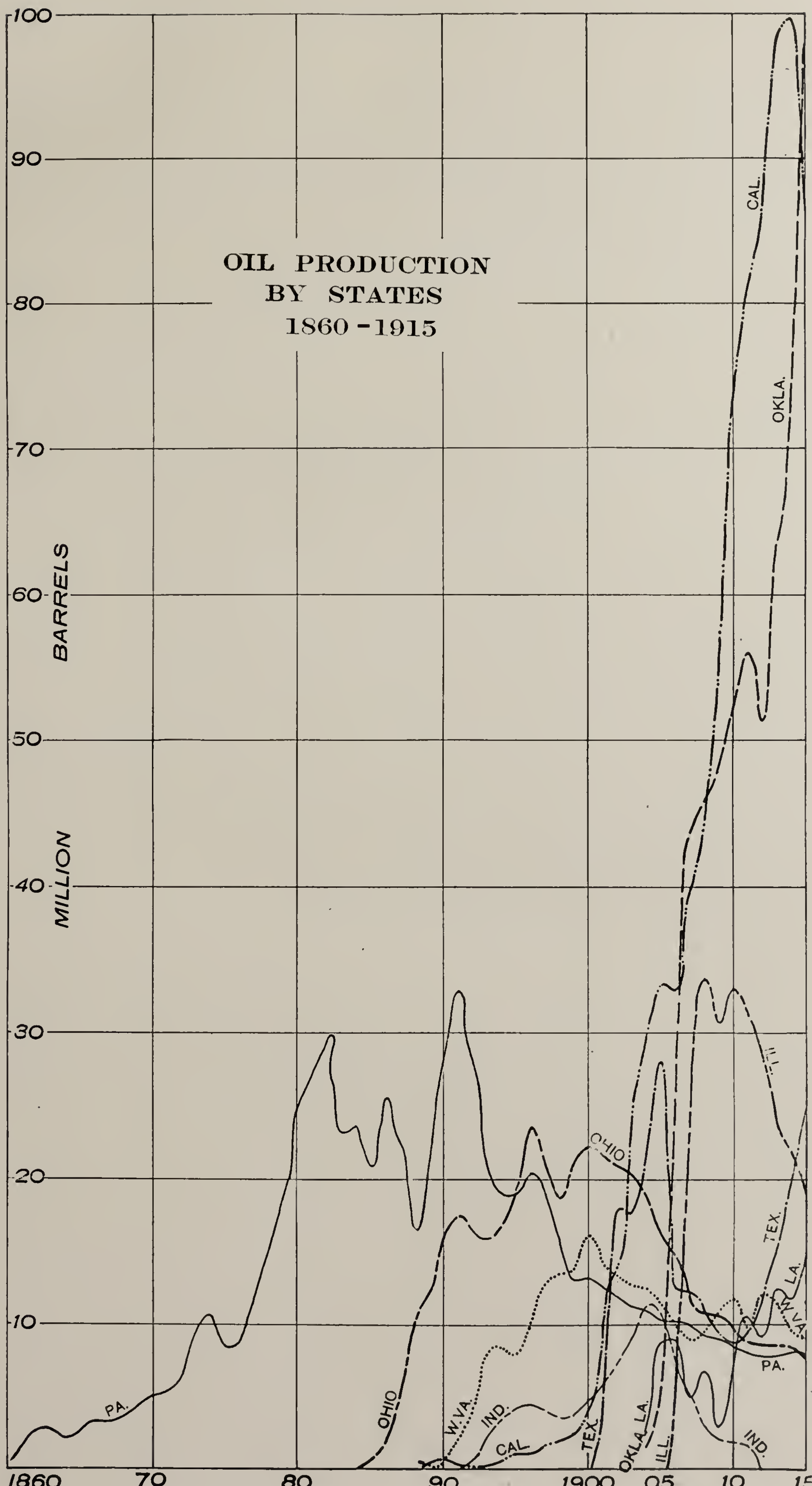


FIG. 3.—Diagram showing production of petroleum in the leading states, 1860-1915

made by the State Geological Survey[3] and by the State and Federal Survey[4] in cooperation.

In southwestern Illinois the greatest development was in Lawrence County where 128 new wells averaged 49 barrels each; in Crawford County 153 wells averaged 12 barrels each. In the western part of the State a small pool was located in Lamoine Township, McDonough County. Activity was slight in the Sandoval pool, Marion County, and in the Carlyle pool, Clinton County.

A detailed account of the developments of the different fields in Illinois is given in a report by F. H. Kay, *Petroleum in Illinois in 1914 and 1915* in this book.

TABLE 11.—*Marketed production in barrels and value of petroleum in Illinois, 1889-1915*

Year	Marketed production	Percentage of U. S. production	Value	Yearly average price per barrel
1889-1904	6,576	....	....	....
1905	181,084	0.14	$ 116,561	$ .644
1906	4,397,050	3.47	3,274,818	.745
1907	24,281,973	14.62	16,432,947	.677
1908	33,686,238	18.76	22,649,561	.672
1909	30,898,339	16.87	19,788,864	.640
1910	33,143,362	15.82	19,669,383	.593
1911	31,317,038	14.21	19,734,339	.630
1912	28,601,308	12.88	24,332,605	.851
1913	23,893,899	9.62	30,971,910	1.296
1914	21,919,749	8.25	25,426,179	1.160
1915	19,041,695	6.77	18,655,850	.979

NATURAL GAS

The amount of natural gas produced for commercial utilization in Illinois continued to decrease. In 1915 there was reported 2,690,593,000 cubic feet valued at $350,371, a drop of about 25 per cent in quantity and 20 per cent in value. The decline was due to natural decrease of pressure and to the lack of drilling occasioned by the depression in the petroleum market throughout most of the year. The gas produced was furnished by 206 producers from 378 wells at the end of the year, 28 having been drilled and 66 abandoned since 1914.

As usual the greater part of the gas came from Cumberland, Clark, Crawford, and Lawrence counties from the shallow sands of the Pennsylvanian and from the deep sands of the Chester series of Mississippian age. Most of the towns in this area use gas almost altogether for lighting and

3Blatchley, Raymond S., Oil and gas in Bond, Macoupin, and Montgomery counties: Ill. State Geol. Survey Bull. 28, 1914. Also, Kay, F. H., Coal resources of District VII: Ill. Coal Mining Investigations Bull. 11, 1915.

4Lee, Wallace, Oil and gas in Gillespie and Mt. Olive quadrangles: Ill. State Geol. Survey Bull. 31, p. 101, 1915.

fuel. At Greenville, Bond County, is a small gas field which derives its supply from the Chester sand.

The most important development in the gas industry resulted from drilling in the Staunton dome described and recommended by the Illinois State Geological Survey. Large volumes of gas issued from several wells put down by Miller Brothers of Staunton and by the Ohio Oil Company. The largest (Daniel Grove No. 1) is reported to have a capacity of 20,000,000 cubic feet per day. For a more detailed description of this drilling, see Mr. Kay's report in this bulletin, *Petroleum in Illinois in 1914 and 1915*.

Another new but small field resulting from recommendation by the Illinois State Geological Survey[5] was in the Spanish Needle Creek dome, sec. 21, T. 9 N., R. 7 W., Macoupin County.

A large number of shallow wells of small volume in Edgar, Logan, Montgomery, Morgan, and Pike counties, and drift wells in Bureau, Champaign, Dewitt, and Lee furnish gas for domestic consumption by one or two families. The village of Heyworth, McLean County, is supplied with gas from the drift.

Table 12 is a record of the natural gas industry in Illinois from 1906 to 1915.

TABLE 12.—*Record of natural gas industry in Illinois, 1906-1915*

Year	Gas produced		Gas consumed			Wells		
	Number of producers	Value	Number of consumers		Value	Drilled		Productive Dec. 31
			Domestic	Industrial		Gas	Dry	
1906	66	$87,211	1,429	2	$87,211	----	----	200
1907	128	143,577	2,126	61	143,577	94	41	283
1908	185	446,077	[a]7,377	[a]204	[a]446,077	121	42	400
1909	194	644,401	[a]8,458	[a]518	[a]644,401	56	11	423
1910	207	613,642	[a]10,109	[a]261	[a]613,642	64	31	458
1911	225	687,726	[a]10,078	[a]293	[a]687,726	69	78	458
1912	223	616,467	[a]10,691	[a]212	[a]616,467	56	147	453
1913	231	574,015	[a]10,423	[a]279	[a]574,015	60	119	455
1914	235	437,275	[a]8,952	[a]153	[a]437,275	38	114	417
1915	221	350,371	8,610	134	350,371	28	67	378

[a]Includes number of consumers and value of gas consumed in Vincennes, Indiana.

GASOLINE

The casing-head gasoline industry in Illinois is of recent development, and not until 1913 was the output especially important. This manufacture of gasoline from natural gas in Illinois is confined to the deep-sand low-pressure fields of Crawford and Lawrence counties where the gasoline

[5]Lee, Wallace, Oil and gas in Gillespie and Mt. Olive quadrangles: Ill. State Geol. Survey Bull. 31, 1915.

content ranges from 2 to 5.5 gallons per thousand feet. Contrary to the condition of the gasoline industry throughout the country, the State fell short of its production for 1914.

TABLE 13.—*Production of gasoline from natural gas in Illinois, 1913-1915*

	1913	1914	1915
Number of plants	12	14	16
Quantity ....gal.	581,171	1,164,178	1,035,204
Value	$67,106	$100,331	$80,049
Price per gallon........cents	11.54	8.62	7.73
Gas used ....cu. ft.	160,304,000	462,321,000	552,054,000
Average yield in gas per M. cu. ft........gal.	3.63	2.52	2.29

ASPHALT

In Illinois asphalt is derived from crude petroleum in refineries. In 1915 the increase in output of this product from Illinois petroleum was very marked—188,575 short tons valued at $1,041,378 as compared with 41,553 short tons valued at $340,862 in 1914. This asphalt is marketed entirely for road oil and for flux.

CLAY-WORKING INDUSTRIES

Clay

In 1915 Illinois dropped from fifth to sixth rank in quantity of production because of a large increase in the output in Georgia, but in the value of the clay mined and marketed it maintained its sixth rank of the previous year. Table 14 shows only a slight increase in the total value of output.

Fire clay, as usual, was the variety of greatest commercial importance, the value of which comprised almost 71 per cent of the total value of clay produced in Illinois, a decided decrease from a proportion of 80 per cent in 1914. The average price, however, increased from $1.11 to $1.27 per ton. The figures for 1915 ranked Illinois fifth among the states producing fire clay. Table 14 shows the increasing importance of this product from 1902 to 1914, and undoubtedy the present decline is only temporary, since the European conditions have greatly increased the demand for the American product. La Salle County, where the clay below coal No. 2 has been found to be very refractory, led in production of fire clay in 1915 with 66,964 tons valued at $86,402, which was 72 per cent of the total State value for fire clay. Other producing counties named in order of decreasing rank in value were Union, Scott, Grundy, Greene and Livingston. McDonough, which stood second in 1914 with a large output of fire clay, reported none of this variety in 1915.

Of the other kinds of clay, McDonough and Greene report stoneware clay valued at $26,165, Greene reported a little brick clay, McDonough a little modeling clay, and Ogle a small amount of clay for medicinal uses.

TABLE 14.—*Production in short tons and value of clay mined and marketed in Illinois, 1902-1915*

Year	Fire clay		Other clays		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1902	(a)	(a)	(a)	(a)	52,152	$38,463
1903	36,239	$38,027	34,799	$35,815	71,038	73,842
1904	55,922	43,863	33,043	27,223	88,965	71,086
1905	50,922	53,726	76,806	66,684	127,728	120,410
1906	44,989	50,793	94,715	81,479	139,704	131,272
1907	66,525	55,545	57,250	50,158	123,775	105,703
1908	39,075	47,039	78,007	67,443	117,082	114,482
1909	45,806	73,884	98,254	76,984	144,060	150,868
1910	82,878	111,078	105,925	79,818	188,803	190,896
1911	71,479	91,623	111,357	92,203	182,836	183,826
1912	92,963	110,204	83,595	82,459	176,558	192,663
1913	106,216	125,477	88,721	78,560	194,937	204,037
1914	125,071	138,876	36,013	29,478	161,084	168,354
1915	93,888	120,008	70,016	49,312	163,904	169,320

[a]Concealed in "Total."

CLAY PRODUCTS

In the total value of clay products Illinois ranked fourth, as it has since 1907, the preceding positions having been held by Ohio, Pennsylvania, and New Jersey. In 1914 this State reported 9 per cent of the total value for the country. In spite of the steady decrease in the number of operating plants during the past ten years (Table 15), the amount and value of total production has remained about the same. The production in 1914 was decidedly less than the previous year, but the figures for 1915 showed an increase of 11 per cent in total value of output.

Almost every variety of clay products was manufactured in Illinois in 1915. In the value and quantity of common brick this State ranked first as it has for a number of years, in the quantity and value of vitrified brick and in the value of terra cotta, second; in the value of enameled brick, third; in the quantity and value of front brick and in the value of draintile, fourth; and in the value of sewerpipe and fireproofing, fifth.

Of the 102 counties in Illinois, 77 reported a production of clay products. The Cook County value of output was 39 per cent of the total value and lay in a production of common brick, architectural terra cotta, fireproofing, tile (not drain), red earthenware, and sanitary ware. No other county reached even the half million dollar mark in value.

As usual common brick comprised the largest portion of the total output of clay products, the value having been 46 per cent of the total. Owing to the large local market Cook County led with 69 per cent of the total value for common brick. Second in importance was vitrified paving brick most of which was from Knox County. Architectural terra cotta ranked

TABLE 15.—*Clay products in Illinois, 1906-1915*

Product	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Brick:										
Common—										
Quantity	1,195,210,000	1,494,807,000	1,119,224,000	1,257,025,000	1,196,526,000	1,074,486,000	1,210,499,000	1,155,480,000	941,343,000	1,066,057,000
Value	$5,719,906	$6,499,777	$4,834,652	$5,927,054	$6,896,836	$6,126,911	$6,437,331	$6,445,821	$4,898,698	$6,870,990
Average per M	$4.79	$4.35	$4.32	$4.72	$5.76	$5.70	$5.32	$5.58	$5.20	$6.45
Vitrified—										
Quantity	122,227,000	126,927,000	138,362,000	140,105,000	115,903,000	124,623,000	136,708,000	133,938,000	157,176,000	142,689,000
Value	$1,306,476	$1,405,821	$1,622,496	$1,562,373	$1,415,355	$1,627,683	$1,839,721	$1,883,199	$2,086,344	$1,796,350
Average per M	$10.69	$11.08	$11.73	$11.15	$12.21	$13.06	$13.46	$14.06	$13.27	$12.59
Front—										
Quantity	30,022,000	20,828,000	22,851,000	32,416,000	22,138,000	19,786,000	21,894,000	29,566,000	46,995,000	58,107,000
Value	$341,298	$266,270	$301,515	$385,170	$274,699	$240,135	$268,433	$363,010	$506,984	$635,686
Average per M	$11.37	$12.78	$13.19	$11.88	$12.41	$12.14	$12.26	$12.28	$10.79	$10.94
Fancy or ornamental....value	$11,635	(a)	(a)	$12,223	$10,875	$10,281	$8,785	$2,295	(a)	(a)
Enameled....value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Fire....value	$236,032	$241,008	$250,444	$682,793	$368,730	$286,039	$319,619	$351,324	$274,106	$320,740
Stove lining....value	(a)	(a)	(a)	--------	--------	--------	--------	--------	(a)	(a)
Draintile....value	$1,052,588	$1,031,192	$1,421,878	$1,613,593	$1,613,698	$1,372,049	$1,189,910	$1,225,190	$1,041,927	$991,709
Sewer pipe....value	$587,805	$662,487	$514,386	$394,461	$538,633	$507,694	$500,844	$787,896	$743,986	$569,536
Architectural terra cotta....value	(a)	(a)	(a)	$1,898,865	$1,680,438	$1,879,275	$2,485,012	$1,908,399	$1,652,945	$1,289,848
Fireproofing....value	$416,928	$429,535	$264,986	$439,796	$552,905	$552,994	$507,222	$592,337	$567,266	$492,138
Tile, not drain....value	(a)	(a)	$124,425	$335,020	(a)	(a)	(a)	$82,168	(a)	(a)
Pottery:										
Red earthenware....value	$37,543	$37,045	$24,821	$31,771	$25,658	$41,875	$35,827	$46,175	$37,452	$40,810
Stoneware and yellow and Rockingham ware....value	$897,650	$898,267	$733,373	$702,411	$708,958	$832,813	$675,244	$624,194	$483,407	$572,958
White ware including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware....value	(a)	(a)	(a)	(a)	--------	(a)	(a)	(a)	(a)	(a)
Sanitary ware....value	--------	--------	--------	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Porcelain electrical supplies....value	(a)	(a)	--------	--------	--------	(a)	(a)	(a)	(a)	(a)
Miscellaneous....value	$2,026,320	$1,749,087	$1,466,138	$358,923	$1,089,376	$855,262	$943,042	$883,866	$1,025,838	$1,211,173
Total value	$12,634,181	$13,220,489	$11,559,114	$14,344,453	$15,176,161	$14,333,011	$15,210,990	$15,195,874	$13,318,953	$14,791,938
Number of active firms reporting	466	417	400	379	346	330	301	281	263	254
Rank of State	5	4	4	4	4	4	4	4	4	4

[a]Included in "Miscellaneous."

TABLE 16.—*Production and value of brick and draintile in Illinois, by counties, 1914 and 1915*

County	1914			1915		
	Common brick		Draintile	Common brick		Draintile
	Thousands	Value	Value	Thousands	Value	Value
Adams	4,553	$32,211	------	5,459	$29,461	------
Bureau	2,677	15,863	$51,314	2,693	16,155	$42,101
Christian	993	7,418	5,791	722	5,580	8,968
Cook	597,694	2,661,476	------	739,173	4,794,452	------
Edgar	------	------	12,700	------	------	(a)
Edwards	2,254	14,403	3,322	485	3,307	(a)
Fulton	8,420	45,690	(a)	5,750	28,800	(a)
Gallatin	461	3,310	3,450	413	3,000	8,000
Grundy	(a)	(a)	63,964	(a)	(a)	47,965
Hancock	1,466	10,605	(a)	1,277	9,558	(a)
Henry	720	5,700	3,176	385	2,715	1,185
Iroquois	284	1,542	54,038	(a)	(a)	33,564
Kankakee	45,487	152,281	(a)	(a)	(a)	(a)
La Salle	2,061	12,555	185,758	3,291	34,071	196,266
Lee	(a)	(a)	(a)	(a)	(a)	27,700
Livingston	12,377	86,569	36,677	14,316	101,281	25,243
Logan	858	5,703	(a)	(a)	(a)	(a)
McDonough	2,450	18,000	27,486	2,400	16,600	52,869
McLean	(a)	(a)	(a)	3,123	19,289	(a)
Macon	6,100	38,700	(a)	7,933	50,000	(a)
Madison	10,416	65,637	(a)	12,990	80,491	(a)
Marion	485	2,813	(a)	(a)	(a)	(a)
Montgomery	2,552	16,243	2,666	813	5,800	3,407
Morgan	1,469	10,807	5,508	1,087	8,621	8,245
Peoria	(a)	(a)	------	2,635	16,800	(a)
Rock Island	4,330	35,608	(a)	2,350	15,915	(a)
St. Clair	28,064	180,070	(a)	(a)	(a)	------
Sangamon	9,014	80,124	36,603	4,570	33,729	(a)
Shelby	(a)	(a)	(a)	262	2,141	5,429
Tazewell	17,607	88,089	(a)	14,190	72,385	(a)
Vermilion	(a)	(a)	5,250	(a)	(a)	5,000
White	1,180	7,995	18,791	680	4,830	15,000
Other counties[b]	177,371	1,299,286	525,433	240,049	1,516,009	510,767
Total	941,343	4,898,698	1,041,927	1,066,057	6,870,990	991,709

[a]Concealed in "Total."

[b]In 1914 including: Boone, Cass, Champaign, Clark, Clinton, Coles, Dekalb, DeWitt, Douglas, Dupage, Effingham, Fayette, Ford, Fulton, Greene, Grundy, Hamilton, Hancock, Jackson, Jefferson, Jersey, Kane, Kankakee, Knox, Lake, Lawrence, Lee, Logan, McLean, Macon, Macoupin, Madison, Marion, Mason, Massac, Menard, Mercer, Monroe, Moultrie, Ogle, Peoria, Pike, Randolph, Richland, Rock Island, St. Clair, Saline, Schuyler, Shelby, Stark, Stephenson, Tazewell, Vermilion, Warren, Washington, Wayne, Will, Williamson, and Woodford counties.

In 1915 including: Boone, Cass, Champaign, Clinton, Dekalb, Dewitt, Douglas, Dupage, Edgar, Effingham, Fayette, Ford, Greene, Hamilton, Iroquois, Jackson, Jersey, Kane, Kankakee, Knox, Lake, Lawrence, Lee, Logan, McLean, Macon, Macoupin, Madison, Marion, Mason, Massac, Menard, Mercer, Monroe, Moultrie, Ogle, Peoria, Pike, Pulaski, Randolph, Richland, Rock Island, St. Clair, Saline, Sangamon, Schuyler, Stark, Tazewell, Vermilion, Warren, Washington, Wayne, Will, Williamson, and Woodford counties.

third in value of the different clay products, and 73 per cent of this output came from Cook County. Fourth in total value is draintile, in production of which La Salle County stood first. Table 16 gives by counties the production and value of common brick and draintile for Illinois in 1914 and 1915. In the manufacture of pottery Illinois has seventh place. In 1915 the production was valued at $948,892 as compared with $780,579 the previous year, an increase of 22 per cent. An increase in the production of each kind of ware was reported. Stoneware constituted 60 per cent of the total for pottery and was made in Brown, Greene, La Salle, McDonough, Tazewell, and Warren, the last named having led with by far the largest amount. Of the other kinds of pottery products, sanitary ware, porcelain, electrical supplies, red earthenware and white ware followed in decreasing order. In 1915 twenty-two operators reported sales.

SANDSTONE AND LIMESTONE

The total value of the material reported as sandstone in 1915 was $43,307, a decrease of about 40 per cent as compared with 1914. The value for 1914, however, (see Table 17) was far in excess of any previous output, and the figure for 1915 is in reality high. Practically all the output was from Alexander County, Lee, Randolph, Union, and St. Clair having quarried small amounts.

The classification as sandstone of the production of these counties is very misleading; the output from Alexander and Union counties is a flint or chert from a 115-foot bed of Devonian age. In Lee County the quarry is operating in a portion of the Platteville-Galena limestone which is soft and granular and might easily be taken for sandstone. In Randolph County the output may be from a sandstone of the Mississippian series; no definite data could be found regarding this quarry. At Chester the Palestine sandstone of the Chester series has been used for building purposes, but no report of production was made in 1914 or 1915.

The value of limestone production in Illinois for 1915 showed an increase of less than one-tenth of one per cent as compared with the preceding year. A study of Table 17 shows that for the last two years this industry has been suffering a decided decline.

Of the 27 counties reporting an output of this product, Cook County as usual led the list with a value $1,429,117, an increase of 8 per cent over the value for 1914, and 49 per cent of the State total. The four counties of following rank were Will, Vermilion, St. Clair, and Kankakee, each having values exceeding one hundred thousand dollars.

Central Illinois is so heavily drift covered that at only a very few locations in this portion of the State have quarries ever been opened. The outcrops are confined almost entirely to the river portions in the northern

part of the State and along the Mississippi (fig. 4). Almost 70 per cent of the value of limestone production in 1915 belonged to the Niagaran which was quarried mostly in Cook, Will, Dupage, and Kane counties; a little came from Savanna and Port Byron on the Mississippi. In the central-northern counties the Platteville-Galena limestone was worked at Rockford, Dixon, Pecatonica, Durand, Mt. Carroll, and other locations. At Moline the Hamilton limestone of Devonian age supplied a small amount, the only place in Illinois where the Devonian was quarried for limestone. Along the Mississippi from Henderson County to Randolph County, and along the Ohio in Pope and Hardin counties outcrops along the bluffs afford economic sites for many quarries. Several of the limestones of Mississippian age in the western and southern portion of the State were worked. The Burlington and Keokuk limestones were quarried at Quincy and Marblehead in Adams County; the Salem limestone at Jonesboro in Union County; the St. Louis limestone at Niota in Hancock County, at Alton in Madison County, south of St. Louis in St. Clair County, and at Elizabethtown in Hardin County; the Ste. Genevieve at Alton in Madison County, south of East St. Louis in St. Clair County, and in the southwest corner of Johnson County; the Yankeetown chert at Millstadt; and a limestone ledge of the Okaw formation at Menard.

Table 17.—*Values of production of sandstone and limestone in Illinois, 1902-1915*

Year	Sandstone	Limestone	Year	Sandstone	Limestone
1902	$ 32,200	$3,222,608	1909	$ 26,891	$4,234,927
1903	26,293	3,206,271	1910	5,710	3,847,715
1904	47,377	3,151,890	1911	30,953	3,436,977
1905	29,115	3,511,890	1912	32,720	3,808,784
1906	19,125	2,942,331	1913	28,781	4,112,172
1907	14,996	3,774,346	1914	72,738	2,861,340
1908	12,218	3,122,552	1915	43,307	2,864,103

Definite geologic data at several other quarry locations along the Mississippi are unavailable. The limestone above coal No. 6 at Belleville was used commercially. In Vermilion County at Fairmount is a lens of limestone in the McLeansboro formation above coal No. 7; this furnishes large amounts of stone for the Chicago steel mills for blast furnace flux and considerable for Portland cement. A limestone of the McLeansboro formation near Casey and Marshall in Clark County was of economic importance in 1915.

Most of the limestone quarried in Illinois is high in magnesium. The Ordovician beds are mainly of this character though a little high-calcium limestone of this age is found. The Silurian (Niagaran) limestones are also magnesian, but the Devonian limestones are very high in percentage of calcium carbonate. Most of the Carboniferous limestones are high in

FIG. 4.—Map showing distribution of limestone quarries, 1915. The figures state the number of quarries at towns having more than one.

calcium and low in magnesium, but the Mississippian limestones are likely to contain a considerable amount of silica in the form of chert.

The value of the stone used for concrete comprised about 36 per cent of the total State value; the value of the stone used for road making, 24 per cent; and the values for flux and railroad ballast each about 12 per cent. Other uses for this product were building, paving, curbing, flagging, rubble, and riprap.

LIME

The lime industry in Illinois has changed very little for several years. In 1915 this State ranked tweflth in quantity and fourteenth in value of production. Though the amount of lime manufactured showed a slight increase, a drop from the average price from $4.38 to $3.98 per ton caused a decrease of about 8 per cent in the total value. As about 50 per cent of the Illinois lime is used for building purposes, this decrease in prices is clearly due to the unfavorable building conditions in Chicago and the three months' strike in the brick trade, thus arousing keen competition for what trade existed. Other uses for the Illinois lime are in chemical works, paper mills, sugar factories, tanneries, and as a fertilizer.

In 1915 lime was burned at 14 plants located in the following counties named in order of rank: Cook, Adams, Madison, Winnebago, Will, and Kankakee. The output of Cook County valued at $183,812 and that of Adams valued at $124,926 comprised almost 88 per cent of the State total.

Both high-calcium and high-magnesium lime was manufactured in Illinois, since both kinds of limestone were quarried. By far the larger percentage was high-magnesium lime which was made in Cook, Will, and Kankakee counties where the Niagaran limestone is used.

Table 18.—*Lime burned in Illinois, 1904-1915*

Year	Number of plants	Quantity	Value	Average price per ton
		Short tons		
1904	....	108,881	$ 461,068	$ 4.23
1905	....	98,907	421,589	4.26
1906	....	121,546	534,118	4.39
1907	22	124,784	559,305	4.48
1908	18	92,549	393,951	4.26
1909	17	104,260	454,682	4.36
1910	14	113,239	503,581	4.45
1911	16	92,169	423,762	4.60
1912	15	98,450	394,892	4.01
1913	16	95,977	433,331	4.51
1914	16	87,603	362,727	4.14
1915	14	88,604	352,954	3.98

CEMENT

In 1915 there were four producing and five shipping Portland cement plants in Illinois at Oglesby (2), Dixon, and South Chicago. Because of the overproduction in 1914, one of the plants temporarily ceased manufacture, and the total for Illinois was 4.5 per cent less than for the previous year; the shipments, however, increased 2.9 per cent. This condition of excessive production of cement was representative of the entire country and considerable caution was exercised in the amount of manufacture of new stock during 1915.

In rank of Portland cement-producing states, Illinois stood third, a position it attained in 1914. During 1915 Pennsylvania manufactured 31 per cent of the total for the United States, Indiana 9 per cent, and Illinois 6 per cent. Table 19 shows the figures for this State from 1900 to 1915.

Analyses[6] of many limestones in Illinois show low magnesia limestones suitable for use in Portland cement manufacture occur in the Ordovician, Mississippian, and Pennsylvanian rocks of this State. As yet only the Ordovician and Pennsylvanian rocks are being used, though the Mississippian limestones would seem to be commercially the most valuable because of their thickness in outcrop, accessibility and proximity to transportation along Mississippi River and railroads, and easly available coal.

A limestone of the Pennsylvanian series (La Salle limestone of the McLeansboro formation) is utilized by the Chicago Portland Cement Company at Oglesby, by the Marquette Cement Manufacturing Company

TABLE 19.—*Portland cement industry in Illinois, 1900-1915*

(Figures opposite P relate to production; those opposite S to shipments.)

Year		Number of plants	Quantity	Value	Average price per barrel
			Barrels		
1900	P	3	240,442	$ 300,552	$1.25
1901	P	4	528,925	581,818	1.10
1902	P	4	767,781	977,541	1.27
1903	P	5	1,257,500	1,914,500	1.52
1904	P	5	1,326,794	1,449,114	1.09
1905	P	5	1,545,500	1,741,150	1.13
1906	P	4	1,858,403	2,461,494	1.33
1907	P	5	2,036,093	2,632,576	1.29
1908	P	5	3,211,168	2,707,044	.84
1909	P	5	4,241,392	3,388,667	.80
1910	P	5	4,459,450	4,119,012	.90
1911	P	5	4,582,341	3,583,301	.79
1912	P	5	4,299,357	3,212,819	....
	S	5	4,602,617	3,444,085	.75
1913	P	5	5,083,799	5,109,218	....
	S	5	4,734,540	4,784,696	1.01
1914	P	5	5,401,605	5,007,288	....
	S	5	5,284,022	4,848,522	.92
1915	P	4	5,156,869	....	....
	S	5	5,435,655	4,884,026	.90

[6]Bleininger, A. V., Lines, E. F., and Layman, F. E., Portland cement resources of Illinois: Ill. State Geol. Survey Bull. 17, pp. 97-100, 1912.

at Dickinson, and by the German-American Portland Cement Company just east of La Salle. The Universal Portland Cement Company uses a mixture of slag and crushed limestone from Fairmount, Vermilion County, where a lens of the McLeansboro limestone outcrops. The Ordovician limestone at Dixon, Lee County, is used by the Sandusky Portland Cement Company.

The Utica Hydraulic Cement Company whose plant began operation under Messrs. Norton and Steele in 1838, is producing a natural cement from the Prairie du Chien ("Lower Magnesian") limestone at Utica and operates one of the twelve natural cement plants of the country. The limestone used comes from two beds, the upper one 6 to 8 feet thick, the lower one 12 to 14 feet thick. The material that is used in the mixture for Portland cement occurs in the proper proportions in this rock. Analyses of these two beds are given below.

Analyses of natural cement rock ("Lower Magnesian") at Utica

Bed	Loss on ignition	Silica (SiO_2)	Iron oxide and alumina (Fe_2O_3, Al_2O_3)	Lime (CaO)	Magnesia (MgO)	Water at 105°
Upper...	38.54	15.02	8.20	25.40	12.50	.33
Lower ..	38.80	14.42	11.34	26.12	9.82	.12

SAND AND GRAVEL

For two years Illinois has taken the lead in total quantity of production of sand and gravel, having displaced New York from first position in 1914. The states following Illinois in order of rank in 1915 were New York, Ohio, Pennsylvania, and Indiana. In value of total output, however, this State continued to hold fourth rank, having been preceded by Pennsylvania, Ohio, and New York.

A comparison of figures for the last two years shows in 1915 an increase of 0.1 per cent in quantity, and 6.7 per cent in value of output of sand and gravel in Illinois. Table 20 shows in general a steady increase in value of sand and gravel production since 1904 when the collection of the statistics for this product was begun.

The sand and gravel in this State is from alluvial deposits, valley trains, pockets in the drift, and outcrops of the St. Peter sandstone. Figure 5 shows the distribution of the pits in 1915. By far the larger production of the output comes from the northern part of the State along Rock River valley and the Fox-Illinois Valley. In this area the valley deposits from the receding glaciers are heaviest.

Of the 37 counties reporting a production of sand and gravel, La Salle County led with an output valued at $429,054, which was 21.6 per cent of the State total; Winnebago County was a close second, its value having

Fig. 5.—Map showing distribution of sand and gravel pits in Illinois, 1915. The figures state the number of pits at towns having more than one.

TABLE 20.—*Production in short tons and values of different kinds of sand and gravel in Illinois, 1904-1915*

Year	Glass sand		Molding sand		Building sand		Grinding and polishing sand		Fire and furnace sand	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1904	219,784	$143,954	574,488	$363,090	338,461	$148,911	--------	--------	44,360	$19,751
1905	234,391	146,605	336,247	189,423	244,297	111,212	--------	--------	13,307	5,312
1906	238,178	156,684	372,307	216,087	868,014	314,071	--------	--------	87,560	38,466
1907	235,716	152,619	372,884	237,149	1,067,776	419,450	--------	--------	22,668	15,017
1908	194,722	139,172	143,080	86,213	1,342.303	481,827	--------	--------	75,762	19,799
1909	224,381	153,226	288,518	143,922	1,917,915	632,273	--------	--------	25,210	15,173
1910	268,654	216,531	407,232	215,742	1,756,652	473,209	--------	--------	97,633	60,932
1911	251,907	171,978	237,359	120,690	1,875,814	691,846	59,880	$41,765	62,107	25,643
1912	323,467	225,434	540,728	268,521	1,910,911	598,884	67,040	49,196	(a)	(a)
1913	350,229	239,227	404,717	181,794	2,299,834	594,687	42,198	23,138	84,801	43,269
1914	339,551	246,803	347,543	200,011	1,196,873	383,209	58,351	38,780	60,674	24,569
1915	566,128	299,286	383,185	195,992	1,600,521	472,654	(a)	(a)	(a)	(a)

Year	Engine sand		Paving sand		Other sands		Gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1904	8,250	$2,120	--------	--------	21,328	$11.914	--------	--------	1,206,671	$689,749
1905	4,062	1,425	--------	--------	518,049	112,761	277,050	$127,034	1,627,403	693,772
1906	70,000	27,400	--------	--------	64,903	32,068	956,597	258,265	2,657,559	1,043,041
1907	113,742	29,091	--------	--------	940,746	133,090	1,797,459	381,237	4,550,991	1,367,653
1908	47,863	8,952	--------	--------	2,047,147	175,941	2,806,871	591,118	6,657,748	1,503,022
1909	104,882	11,242	--------	--------	3,188,885	277,056	3,405,438	716,605	9,155,229	1,949,497
1910	43,147	6,840	--------	--------	1,211,564	130,756	4,801,626	626,785	8,586,508	1,730,795
1911	46,897	6,158	318,671	$125,624	1,862,000	164,292	3,774,048	642,926	8,488,683	1,990,922
1912	59,151	12,916	30,581	13,958	499,685	75,391	3,481,638	664,552	6,957,901	1,929,822
1913	79,568	11,166	101,631	30,973	171,898	77,252	4,457,264	868,985	7,992,140	2,070,491
1914	93,299	12,239	121,812	39,851	522,808	120,635	4,955,219	793,422	7,696,130	1,859,519
1915	73,427	14,677	291,436	73,645	8,376	4,402	4,424,527	885,548	7,708,012	1,984,569

[a] Concealed in "Total".

TABLE 21.—*Production in short tons, and value of sand*

1914

County	Producers	Glass sand		Molding sand		Building sand		Grinding and polishing sand		Fire or furnace sand
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity
Bond	5	--------	--------	13,510	$13,018	(a)	(a)	--------	--------	--------
Bureau	8	--------	--------	(a)	(a)	13,649	$3,496	--------	--------	--------
Carroll	3	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Cook	4	--------	--------	--------	--------	(a)	(a)	--------	--------	--------
Kane	12	--------	--------	120,293	24,605	148,483	39,064	--------	--------	--------
La Salle	18	273,334	$207,195	168,978	129,764	(a)	(a)	58,351	$38,780	60,67
Lee	6	--------	--------	--------	--------	3,300	1,500	--------	--------	--------
McHenry	6	(a)	(a)	(a)	(a)	198,240	61,124	--------	--------	--------
Madison	3	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Ogle	4	(a)	(a)	--------	--------	--------	--------	--------	--------	--------
Peoria	12	--------	--------	(a)	(a)	38,892	16,519	--------	--------	--------
Rock Island	7	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Tazewell	4	--------	--------	--------	--------	18,310	10,117	--------	--------	--------
Whiteside	5	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Will	7	--------	--------	(a)	(a)	8,404	3,367	--------	--------	--------
Winnebago	7	--------	--------	12,739	8,010	241,970	86,413	--------	--------	--------
Other counties[b]	21	3,000	2,550	5,499	5,287	331,328	87,400	--------	--------	--------
State total	133	339,551	$246,803	347,543	$200,011	1,196,873	$383,209	58,351	$38,780	60,67

[a]Concealed in totals.

[b]Including: Alexander, Boone, Cass, Clinton, Dekalb, Dupage, Henderson, Kendall, Lake, Logan, Menard

1915

County	Producers	Glass sand		Molding sand		Building sand		Grinding and polinshing sand		Fire or furnace sand
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity
Bond	6	--------	--------	18,387	$14,902	3,700	$1,395	--------	--------	--------
Bureau	8	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Carroll	3	--------	--------	--------	--------	(a)	(a)	--------	--------	--------
Cook	4	--------	--------	--------	--------	194,336	107,475	--------	--------	--------
Kane	10	--------	--------	23,169	11,584	393,402	75,209	--------	--------	--------
Lake	3	--------	--------	--------	--------	(a)	(a)	--------	--------	--------
La Salle	18	495,884	$251,552	260,207	115,168	(a)	(a)	62,366	$26,370	(a)
Lee	6	--------	--------	--------	--------	6,900	1,800	--------	--------	--------
McHenry	5	--------	--------	(a)	(a)	41,745	15,482	--------	--------	--------
Madison	3	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Ogle	5	(a)	(a)	--------	--------	(a)	(a)	--------	--------	--------
Peoria	10	--------	--------	--------	--------	41,710	23,700	--------	--------	--------
Rock Island	7	--------	--------	(a)	(a)	110,390	28,508	--------	--------	--------
Tazewell	4	--------	--------	--------	--------	43,338	11,780	--------	--------	--------
Whiteside	7	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Will	5	--------	--------	(a)	(a)	10,305	3,950	--------	--------	--------
Winnebago	6	--------	--------	(a)	(a)	(a)	(a)	--------	--------	--------
Other counties[b]	20	2,500	2,125	28,999	13,975	385,100	105,899	--------	--------	--------
State total	127	566,128	$299,286	383,185	$195,992	1,600,521	$472,654	62,366	$26,370	(a)

[a]Concealed in totals.

[b]Including: Alexander, Boone, Cass, Dekalb, Dupage, Fayette, Fulton, Henderson, Jo Daviess, Kendall,

gravel in Illinois, by counties, 1914 and 1915

furn- sand	Engine sand		Paving sand		Other sands		Gravel		Total	
lue	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
----	--------	--------	(a)	(a)	700	$100	(a)	(a)	17,445	$14,223
----	(a)	(a)	(a)	(a)	--------	--------	49,272	$18,536	66,788	24,352
----	--------	--------	--------	--------	--------	--------	(a)	(a)	6,640	2,875
----	--------	--------	(a)	(a)	156,638	26,106	227,445	32,201	541,858	121,377
----	--------	--------	--------	--------	48,807	16,270	294,986	69,696	621,569	139,635
,569	(a)	(a)	--------	--------	17,374	11,743	705,860	80,877	1,294,821	499,028
----	--------	--------	(a)	(a)	--------	--------	13,040	2,140	22,190	4,840
----	--------	--------	--------	--------	109,897	9,825	118,897	32,289	433,970	107,953
----	--------	--------	--------	--------	965	750	--------	--------	91,127	25,345
----	--------	--------	--------	--------	--------	--------	190,000	21,165	252,281	57,708
----	--------	--------	(a)	(a)	16,290	5,702	144,444	54,341	204,699	78,579
----	--------	--------	--------	--------	37,800	14,000	80,983	24,475	174,624	55,019
----	(a)	(a)	(a)	(a)	--------	--------	582,237	74,983	630,766	95,932
----	(a)	(a)	(a)	(a)	1,804	810	17,175	12,025	64,634	16,539
----	--------	--------	--------	--------	65,810	19,669	807,364	195,386	889,578	222,422
----	--------	--------	(a)	(a)	887	20	791,049	32,089	1,048,071	126,564
----	41,293	4,655	51,306	15,622	65,836	15,640	938,497	343,271	1,436,759	474,425
,569	93,299	$12,239	121,812	$39,851	522,808	$120.635	4,955,219	$793,422	7,696,130	$1,859,519

er, Monroe, Piatt, Pike, St. Clair, Sangamon, Wabash, and White counties.

r furn- sand	Engine sand		Paving sand		Other sands		Gravel		Total	
lue	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
----	(a)	(a)	(a)	(a)	--------	--------	(a)	(a)	23,594	$17,399
----	(a)	(a)	--------	--------	--------	--------	65,771	$21,111	84,221	26,504
----	--------	--------	(a)	(a)	--------	--------	4,153	1,328	5,548	2,453
----	--------	--------	--------	--------	--------	--------	547,991	96,325	742,327	203,800
----	--------	--------	--------	--------	1,500	$200	349,273	147,296	767,344	234,289
----	--------	--------	--------	--------	--------	--------	208,640	37,208	343,640	71,208
)	(a)	(a)	--------	--------	5,000	3,000	20,513	9,519	1,160,266	429,054
----	--------	--------	(a)	(a)	--------	--------	7,221	1,925	14,621	3,825
----	--------	--------	--------	--------	--------	--------	(a)	(a)	58,194	23,605
----	--------	--------	--------	--------	1,509	1,125	--------	--------	95,046	26,194
----	--------	--------	(a)	(a)	--------	--------	321,415	23,325	398,909	72,534
----	--------	--------	(a)	(a)	--------	--------	154,966	55,200	196,946	78,980
----	--------	--------	--------	--------	--------	--------	72,253	20,711	185,867	51,882
----	--------	--------	72,255	$21,834	--------	--------	(a)	(a)	234,599	77,934
----	(a)	(a)	(a)	(a)	--------	--------	69,615	28,590	98,646	36,977
----	--------	--------	--------	--------	--------	--------	--------	--------	33,234	15,926
----	--------	--------	(a)	(a)	--------	--------	2,091,145	297,510	2,368,515	371,313
----	49,002	6,471	43,755	12,495	376	77	386,763	99,640	886,495	240,682
'	73,427	$14,677	291,436	$73,645	8,376	$4,402	4,424,527	$885,548	7,708,012	$1,984,569

in, Menard, Mercer, Monroe, Pike, St. Clair, Sangamon, Wabash, and White counties.

been $371,313, which was 18.7 per cent of the total. Kane and Cook counties held the third and fourth ranks with values exceeding a hundred thousand dollars. In 1914 six counties exceeded this value—La Salle, Will, Kane, Winnebago, and McHenry—but the value of output for Will County fell to only 7.1 per cent that of the previous year, but that for McHenry County to 21.8 per cent. Table 21 gives the detailed production of the different kinds of sand and gravel by counties, where three or more producers are represented.

The production and value of glass sand in Illinois, as for the entire country, was the largest ever reported, and for the first time this State led in its quantity of output and relegated Pennsylvania to second place. In value, however, the ranks of these two states were reversed. The 66 per cent increase in tonnage of glass sand arose from the decided increase in demand by the glass manufacturers in this country, since imports of glass have decreased and exports increased. This activity still continues. The average price per ton fell from 73 cents in 1914 to 53 cents in 1915.

In Illinois excellent glass sand comes from the pure and friable St. Peter sandstone which outcrops in Upper Illinois Valley and Rock River Valley. In 1915 glass sand was mined at Utica, Ottawa, Wedron, Seneca, Millington, and Oregon, as shown on the map, figure 5. At many other localities along the Rock and Illinois rivers this formation might be profitably worked; and in Calhoun County between West Point and Dogtown its outcrop is about 150 feet in thickness. It is reported that a glass sand deposit occurs at Greenville, Bond County.

An increase of 10 per cent in amount of molding sand results from increased demand of the manufacturers of machinery and munitions. The average price per ton, however, fell from 57 cents per ton to 51 cents, and the total value of molding sand was less in 1915 than the previous year.

FLUORSPAR

Since 1905 Illinois has led in the production of fluorspar and Kentucky now holds second place. The total output of fluorspar in 1915 was the largest in the history of the State, but as the production was from only two producers the figures must be concealed. This enormous increase is in harmony with the increased activity in steel manufacturing. The value of the output, however, was not so high as in 1912 (Table 22). This decline in value per ton has been caused largely by the improvements in milling and handling of larger quantities; but it is believed that the operators have kept the price down in order to procure and to hold for domestic spar the eastern markets, formerly supplied by importations of spar which have been interrupted by the European war. Heretofore the imported material has been slightly cheaper for eastern markets, but that

from Illinois is much purer and it is hoped by the producers that in the future the imported spar will not be in demand.

The Illinois-Kentucky district is practically the only source of spar for the American market and the product is used in steel-making and foundry work mainly; only a small fraction of the output contains less than 1 per cent silica and is used in enameling, chemical, and glass trades. The commercial importance of the Illinois fluorspar district is rapidly growing. The small mines in the Rocky Mountain region can hardly ever expect to compete with those in Illinois, as the proximity of our location to the steel mills gives these mines a decided advantage. Illinois produces almost five times as much as Kentucky, Colorado, New Mexico, and New Hampshire together. The two leading operators have during the last year been extending their workings considerably, and 1916 promises to be a record breaker.

In Pope and Hardin counties the fluorspar accompanied by smaller amounts of many other minerals, occurs in fissure veins that mark planes of extensive faulting. These tabular ore bodies are commonly 10 to 12 feet thick and in places attain a thickness of 25 feet. By far the largest ore body is the Fairview-Rosiclare which consists of two veins having a northeasterly trend and merging just south of the Rosiclare mine. The two active mines for 1915 were the Fairview and Rosiclare which had operated steadily for a great many years. They have reached depths exceeding 400 and 500 feet and find the veins of undiminished strength and thickness.

TABLE 22.—*Production in short tons and value of fluorspar in Illinois, 1902-1915*

Year	Quantity	Value	Year	Quantity	Value
1902	18,360	$121,532	1909	41,852	$232,251
1903	11,413	57,620	1910	47,302	277,764
1904	17,205	122,172	1911	68,817	481,635
1905	33,275	220,206	1912	114,410	756,653
1906	28,268	160,623	1913	85,854	550,815
1907	25,128	141,971	1914	73,811	426,063
1908	31,727	172,838	1915	(a)	(a)

[a]Concealed because of only two producers.

MINERAL WATERS

The production of mineral waters in Illinois for 1915 was from 23 springs, Gravel Springs near Jacksonville, Morgan County, having produced by far the largest amount. Four new wells reported an output, and two ceased commercial production. Table 23 shows a decrease as compared with 1914 which was the record year. The price per gallon is steadily falling, due probably to the improvement of municipal supplies.

TABLE 23.—*Production in gallons and value of mineral waters in Illinois, 1903-1915*

Year	Number of springs	Quantity	Value	Average price per gallon
1903	20	1,118,240	$149,978	$0.13
1904	14	392,800	38,096	.10
1905	11	425,750	47,995	.11
1906	15	574,453	77,287	.14
1907	15	720,400	91,760	.13
1908	17	685,763	58,904	.09
1909	14	639,460	49,108	.08
1910	16	1,117,620	83,148	.07
1911	14	1,304,950	82,330	.06
1912	17	1,143,625	74,445	.07
1913	21	1,216,442	68,549	.06
1914	21	1,760,030	81,307	.05
1915	23	1,559,489	75,290	.05

SILICA

Two forms of silica were mined commercially in Illinois in 1915—tripoli and quartz. The production of tripoli in 1915 by four operators in Alexander and Union counties far exceeded that of any other year (Table 24). Because of the check on importation, this country has been forced to look to its own resources for supplies, and it has been found that the heavy beds of disintegrated Devonian chert that outcrop in great thicknesses in southern Illinois are a very satisfactory substitute for the imported French chert used in the manufacture of the high-grade white ware. The ground quartz sand of Ottawa (St. Peter sandstone) is also used somewhat, but the amorphous silica or tripoli is better adapted for this purpose. It has been partly this new use that has increased the demand for the Illinois product. Missouri has produced small amounts used in making filters, but Illinois is the main source of this product.

TABLE 24.—*Production in short tons and value of tripoli mined in Illinois, 1909-1915*

Year	Quantity	Value
1909	....	$ 38,262
1910	....	33,390
1911	....	45,910
1912	....	27,339
1913	12,994	128,892
1914	10,387	59,394
1915	23,756	502,937

The Illinois tripoli has been used for some time as a paint, wood filler, metal polish, in soaps, cleansers, glass manufacture, and for facing foundry molds. The process of preparation consists essentially in fine crushing and careful sizing, since the value of any grade depends mainly on the fineness and uniformity of grain. Silica employed in the pottery business must be free from contamination by iron. Considerable interest in the exploita-

tion of the Illinois deposit is now being shown, and undoubtedly a new and rapid growth has begun.

PYRITE AND SULPHURIC ACID

A decrease of 34 per cent in quantity of output of pyrite was suffered in 1915. The rank of Illinois, however, still remained fourth, having been preceded by Virginia, California, and Ohio. Throughout the country a large demand for pyrite for the manufacture of sulphuric acid made the total United States production much larger than ever before.

The industry of pyrite-mining in Illinois is only incidental, and is associated with coal mining. Especially in Vermilion County the value of whose production was almost 100 per cent of the State total, is the industry developed, since the pyrite (or marcasite in reality) occurs in the coal of this district in distinct lenses and bands instead of being finely disseminated throughout the coal as in most parts of the State. Madison

TABLE 25.—*Production in long tons and value of pyrite mined in Illinois, 1909-1915*

Year	Quantity	Value	Average price per ton
1909	5,600	$17,551	$2.60
1910	8,541	28,159	3.30
1911	17,441	47,020	2.70
1912	27,008	62,980	2.33
1913	11,246	31,966	2.84
1914	22,538	59,079	2.62
1915	14,849	22,476	1.51

County reported a very small production. Miners are paid by the ton for the pyrite thrown out of the coal, an inducement to load as clean and marketable coal as possible.

Table 25 gives the production of pyrite from 1909 to 1914. Previous to 1909 the reports of production were combined with those of Indiana.

The sulphuric acid produced in Illinois is a by-product in the smelting of zinc in which process the waste gases, sulphur dioxide and sulphur trioxide, are converted into acid. The grade, 60° Beaumé, given in Table 5 is 78.04 per cent sulphuric acid, and the amount produced in Illinois smelters in 1914 was equivalent to about 111,000 long tons of pyrite associated with the ore; as the acids as reported for 1915 were not convertible to the same strength, the quantity can not be stated.

LEAD, ZINC, AND SILVER

The lead and zinc deposits of Illinois fall into two distinct areas of very different geologic character. Those of northern Illinois occur in the gently folded Galena dolomite and upper part of the Platteville limestone, both of Ordovician age. Those in Hardin and Pope counties are

associated with fluorspar in fissure veins controlled by jointing and faulting in the Mississippian limestones in the northern extension of the Kentucky-Illinois fluorspar district.

Northern Illinois.—The increasing importance of zinc in northern Illinois is shown in Table 27, practically none having been produced in the southern section. The entire output for northern Illinois in 1915 was from the Galena district where the quantity of lead produced was practically the same as for the previous year, but the total value was 21 per cent greater. The output of zinc increased 15 per cent and the value 179 per cent. The tenor of the ore produced is shown in Table 26.

The Galena district has shown considerable activity and development during the past year. The Vinegar Hill Zinc Company drilled 13 holes on one lease and will mine there during 1916; on another lease 36 holes were put down, a shaft sunk, and a 200-ton concentrating plant begun. The Wisconsin Company is developing the Birbeck mine extensively and has completely rebuilt the property of the Joplin Separating Company that was destroyed by fire in 1910. The Pittsburg mine claims a new roasting and separating plant for 1915.

The largest production of lead and zinc concentrates in northern Illinois in 1915, as the previous year, was from the old Marsden-Black Jack mine of the Mineral Point Zinc Company; second in production was the Pittsburg mine of the Great Western Lead Manufacturing Company; and the third in output was the North Unity mine of the Vinegar Hill Zinc Company. Other smaller mines reported activity.

Southern Illinois.—In the southern district the lead and silver are recovered as by-products in the concentration of the fluorspar with which the argentiferous galena is associated in the veins. Therefore since the fluorspar production was decidedly greater in 1915 than the year before, the increase in lead and silver was also marked. No shipments of zinc ore have been reported since 1906. The difficulty of making a clean separation of the zinc middlings has kept down the output of this product in southern Illinois. In 1915 the quantity of lead produced was slightly more than double that for 1914, and the value 146 per cent greater. The increase in the quantity of silver was 83 per cent, in the value 68 per cent.

The galena of southern Illinois is notable argentiferous, the silver content ranging up to 12 and 14 fine ounces per ton of lead concentrates, and averaging for the last five years 4 to 7 fine ounces per ton. The average silver content per ton recovered from the lead concentrates decreased from 6.86 ounces in 1914 to 6.03 ounces in 1915.

The largest producer of fluorspar and lead cencentrates in southern Illinois is the Rosiclare Lead and Fluorspar Company which has a long and steady record of production and is now mining at a depth of more than 500 feet and possesses a modern equipment sufficient to handle 500

Table 26.—*Tenor of lead and zinc ore and concentrates in Illinois, 1914 and 1915*

	1914	1915
NORTHERN ILLINOIS		
Total crude ore ---- short tons ----	261,300	316,000
Total concentrates in crude ore:		
Lead ---- per cent ----	0.25	0.22
Zinc ---- per cent ----	6.4	6.5
Metallic content of crude ore:		
Lead ---- per cent ----	.19	.17
Zinc ---- per cent ----	2.3	2.18
Average lead content of galena concentrates ---- per cent ----	76.2	72.9
Average zinc content of sphalerite concentrates ---- per cent ----	36.5	33.5
Average value per ton:		
Galena concentrates ----	$44.70	$47.27
Sphalerite concentrates ----	$19.13	$36.73
SOUTHERN ILLINOIS		
Average lead content of galena concentrates ---- per cent ----	73.5	71.6
Average value per ton of galena concentrates ----	$39.99	$43.45

Table 27.—*Production and value of lead, zinc, and silver in Illinois, 1907-1915*

Year	District	Lead		Zinc		Silver	
		Quantity	Value	Quantity	Value	Quantity	Value
		Short tons		*Short tons*		*Fine ounces*	
1907	Total	830	$87,980	737	$ 86,966	2,852	1,882
1908	Total	399	33,516	1,717	161,398	2,051	1,087
1909	Northern Illinois	88	7,566	2,163	223,604	....	....
	Southern Illinois	207	17,804	....	......	1,011	526
	Total	295	25,370				
1910	Northern Illinois	101	8,888	3,549	383,292	....	....
	Southern Illinois	272	23,936	....	......	2,022	1,092
	Total	373	32,824				
1911	Northern Illinois	625	56,250	4,219	480,966	....	....
	Southern Illinois	339	30,510	....	......	3,036	1,609
	Total	964	86.760				
1912	Northern Illinois	687	61,830	4,065	560,970	....	....
	Southern Illinois	595	53,550	....	......	4,731	2,909
	Total	1,282	115,380				
1913	Northern Illinois	588	51,744	2,236	250,432	....	....
	Southern Illinois	371	32,648	....	......	3,541	2,139
	Total	959	84,392				
1914	Northern Illinois	492	38,376	4,811	490,722	....	....
	Southern Illinois	225	17,550	....	......	2,112	1,168
	Total	717	55,392				
1915	Northern Illinois	495	46,530	5,534	1,372,432	....	....
	Southern Illinois	459	43,146	....	......	3,864	1,959
	Total	954	89,676				

tons daily. The Fairview Fluorspar and Lead Company is another large operator which is planning further development of the Good Hope vein which it has been working since 1862. A new shaft has been put down, and prospects seem favorable for increased activity.

MINERAL PAINTS

In 1915 the pigments made in Illinois directly from the ores were sublimed white lead or "basic lead sulphate" and sublimed blue lead or "blue fume"; the St. Louis Smelting and Refining Company at Collinsville is one of two firms manufacturing this product in the United States. The chemically manufactured pigments made at Chicago, Argo, and East St. Louis were litharge or lead monoxide; lithopone or a mixture of about 70 per cent barium sulphate, from 25 to 29 per cent zinc sulphide, and from 1 to 5 per cent zinc oxide; red lead which is produced by heating litharge; and basic carbonate, white lead which contains about 85 per cent lead oxide and 15 per cent carbon dioxide and water. The total value of all these products was $6,195,435, but only the value for sublimed lead was included in the total Illinois value of mineral products, as duplication would be involved if the others were also included.

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PETROLEUM IN ILLINOIS IN 1914 AND 1915

By Fred H. Kay

OUTLINE

TABLES

GENERAL REVIEW

The production of oil in Illinois continued to decline in 1914 and 1915. The former year as compared with 1913 showed a decrease of 1,974,150 barrels, or 8.2 per cent; whereas in 1915 the production was 19,041,695, a decline of 13.6 per cent. Table 28 shows the annual production and value of Illinois oil from 1905 to 1915 inclusive. The State reached its greatest output in 1908, when it produced 33,686,238 barrels. It continued to produce more than 30,000,000 barrels until 1912, but a

steady decline has been in progress since 1911. The new fields that have been discovered have not been able to overcome the normal decline in the output of Crawford, Lawrence, and Clark counties.

TABLE 28.—*Illinois oil production, 1905–1915*

Year	Barrels	Value
Previous	6,576	$ ....
1905	181,084	116,561
1906	4 397,050	3.274.818
1907	24,281,973	16.432,947
1908	33,686,238	22,649,561
1909	30,898,339	19,788,864
1910	33,143,362	19,669,383
1911	31,317,038	19,734,339
1912	28,601,308	24.332,605
1913	23 893,899	30,971,910
1914	21,919,749	25,426,179
1915	19,041.695	18,655,850

The State maintained its rank as third in production until 1915 when the discovery of new prolific fields in Texas forced Illinois into fourth place, and unless some unexpected discovery is made, it will probably be compelled to yield its present rank to Louisiana in 1916.

The first half of 1914 was characterized by a considerable amount of development work which was stimulated by the strong market. The declining prices prevailing during the latter months resulted in a marked decrease in the number of well completions. Inactivity continued until the latter months of 1915 when the rapidly advancing prices brought a response which augurs well for the coming year. Table 29 shows the fluctuation in price per barrel for the years 1914 and 1915.

In 1914, according to J. D. Northrup,[1] 1,579 wells were completed, of which number 1,163 or nearly 74 per cent yielded an average initial production of 33.75 barrels per well per day; 28, or about 1 per cent were gas wells, and the remaining 388, or 25 per cent were barren. In 1915 only 756 wells were completed, according to the *Oil and Gas Journal* and the *Oil City Derrick*. Of these 72 per cent yielded an initial production of 26 barrels each; 18, or 2 per cent, were gas wells and 197, or 26 per cent, were dry.

[1]Northrup, J. D., Illinois oil field: U. S. Geol. Survey Mineral Resources, 1914, pp. 984-992, 1916.

Table 29.—*Fluctuation in prices, per barrel, of Illinois petroleum, 1914-1915*

Date	1914	Date	1915
Jan. 1	$1.45	Feb. 16	$0.84
April 18	1.40	Aug. 12	0.89
April 22	1.35	Aug. 20	0.94
April 28	1.30	Aug. 23	0.99
May 1	1.25	Sept. 4	1.04
May 5	1.20	Sept. 15	1.09
May 12	1.15	Sept. 27	1.12
June 17	1.12	Oct. 5	1.17
Aug. 1	1.07	Oct. 23	1.27
Aug. 7	1.02	Nov. 15	1.32
Sept. 14	0.97	Nov. 17	1.37
Sept. 23	0.92	Dec. 3	1.42
Oct. 26	0.89	Dec. 15	1.47
		Jan. 3, 1916	1.57
Average	$1.16	Average	$0.992

At the beginning of 1914, stocks in Illinois aggregated 8,179,351 barrels. There was a gradual accumulation of oil in storage throughout the year and on Dec. 1, 1914, the tanks held 13,563,743 barrels. On Jan. 1, 1915 the Ohio Oil Company stocks amounted to 12,375,165 barrels, but by Feb. 1 they had been reduced to 3,675,839 barrels. The remainder of the year showed only minor fluctuations and on Dec. 1, 1915 this company held 5,234,963 barrels in storage.

The decline of high grade production from the Cushing, Oklahoma, field, the more normal export conditions, and the constantly increasing demand for motor fuels have resulted in a phenomenal rise in prices and have started the oil industry on its way to unprecedented development. The coming year will no doubt see wildcatting on a large scale in an effort to locate new fields.

SOUTHEASTERN ILLINOIS

Cumberland, Coles, Clark, Jasper, and Edgar Counties

Out of a total of 1,579 wells drilled in Illinois in 1914, 271 or 17 per cent, were in the shallow-sand fields of Cumberland, Coles, Clark, Jasper, and Edgar counties. The production in this area comes from lenticular sandstones and porous limestones which vary in depth from 350 feet to about 600 feet. Initial production varies from 5 to 10 barrels but within 3 or 4 months it declines to less than 5 barrels. Many of the wells in the Casey pool now yield an average of only 1¾ barrels per day.

In 1915, out of a total of 756 wells, 192 were drilled in the shallow territory. Attention was naturally directed to this area on account of the low drilling cost as compared to the deep sand territory of Lawrence County.

In Cumberland County slight additions to the productive territory were made in 1914, but during the 2-year period included in this report most of the drilling has been confined to inside locations, that had been neglected as long as higher-yielding territory was available. The drilling of new wells within 30 or 40 feet of old ones has been attended with some success in parts of the shallow-sand area. In most places it is found that the initial yield of the new well very nearly equals the initial production of the old well which may have been producing 5 or 6 years. The explanation probably lies in the fact that the sands near the old wells become so clogged with paraffin that the ordinary methods of cleaning do not render the pores free from wax. Re-shooting in many instances produces no beneficial effect, whereas the drilling of another hole about 40 feet distant taps the sand where it is fresh and where the oil has free access to the well.

The producing sands of the shallow fields are "spotty" and irregular and the finding of a dry hole means only that the sand is absent at that location. A producer may be brought in a short distance away.

Crawford County

general conditions

In 1915, only 215 wells were drilled in Crawford County, as compared with 706 completed during 1914. A large part of this drilling was routine, deepening of old wells and drilling inside locations. Town-lot excitement prevailed at Robinson during the early part of 1914 but the area was rapidly drilled and almost exhausted.

Most of the new drilling at the close of 1915 was in Honey Creek Township, secs. 2, 3, 13 and 24, T. 5 N., R. 12 W.; secs. 18 and 19, T. 5 N., R. 11 W.; and secs. 34 and 35, T. 6 N., R. 12 W. Of these secs. 13, 18, 19, and 24 had not been drilled until the latter part of 1914. Secs. 2 and 3 constituted the Shaffer and Smathers gas area, which has now been drilled to oil sands below the gas. The initial production of about 35 barrels declines rapidly to about 2 barrels per day.

On Jan. 1, 1915, according to Mr. W. W. McDonald of the Ohio Oil Company, the average settled production of Crawford County wells was 2.8 barrels each and by the end of the year it had dropped to about 2.4 barrels each.

The production of the wells in secs. 15 and 16, T. 5 N., R. 12 W. (Honey Creek), holds up better than in any other part of the county. The wells are almost 7 years old and their average daily production is about 4.2 barrels or 75 per cent greater than the average for the county. The wells in the heavy oil district north of Flat Rock are showing remarkable staying qualities. New wells between old ones have about the same initial production as the original wells and the decline is slow. The pool seems to lie along the axis of a narrow anticline which extends northeast at right angles

to the La Salle anticline. The oil increases in gravity toward the northeast along this small fold. The sands dip below the level of salt water northwest and southeast of the pool, and production is limited to a strip about ½ mile wide.

Wells in the Flat Rock pool show about four times as much water as in any other part of the county south of the Bellair pool, in the northwest part of the county. Salt water is especially troublesome in sec. 11, T. 8 N., R. 14 W. (Licking) ; in secs. 30, 31, T. 6 N., R. 11 W., and 36, T. 6 N., 12 W. (Honey Creek) ; and in sec. 29, T. 6 N., R. 11 W. (Montgomery). Much of the casing is corroded in 4 or 5 months to such a degree that it must be replaced. The Ohio Oil Company now purchases only copperized casing and it is believed that corrosion will be lessened, although this type has not been in use long enough to determine whether or not the increased life of the casing will offset its higher cost. It is now proposed to pump mud-laden fluid into the well outside of the casing in order to shut off acid waters near the coal beds. Its usefulness in this field has not yet been demonstrated, but since it has been used successfully in California and Oklahoma for sealing up sands containing gas under high pressure, there appears to be no reason why it could not be used to prevent strong acid waters from reaching the outside of the casing. However, this will not be effective so far as the water in the oil sand is concerned.

DEEP SANDS IN CRAWFORD COUNTY

In Honey Creek Township, secs. 2, 3, and 4, T. 5 N., R. 12 W., and secs. 34 and 35, T. 6 N., R. 12 W., wells were formerly drilled to a depth of 1000 feet as in the Parker pool, and only gas was produced. Within the last year and a half the Ohio Oil Company has drilled 75 feet deeper and into an oil sand which, although not so productive as the sands in the Parker pool, nevertheless shows wells with an initial production of 40 or 50 barrels per day. A decline of 50 per cent occurs during the first month and continues to a settled production of 5 or 6 barrels per day.

In Oblong Township, secs. 17, 18, 19, and 20, T. 7 N., R. 13 W., producing sands are found at about 1,320 and 1,400 feet; and in sec. 3, T. 5 N., R. 12 W., and sec. 28, T. 6 N., R. 12 W., of Honey Creek Township, Shaffer and Smathers found gas and sour oil at 1,520 feet in mixed sand and limestone, which probably represents the McClosky. Limestone was found to a depth of 2,225 feet.

At the center SE. ¼ sec. 27, T. 6 N., R. 13 W. (Martin), and Ohio Oil Company found the McClosky sand at 1,260 feet. The well was exhausted after 2 years' pumping. In the NW. ¼ SE. ¼ sec. 15, T. 5 N., R. 12 W. (Honey Creek), the top of the lime from 1,510 to 1,540 feet is filled with salt water.

WILDCATTING IN CRAWFORD COUNTY

The narrow anticlines that extend northeast from Flat Rock and Birds, as shown by the present producing areas and the gas wells that have been drilled at various places in the east side of the county, have encouraged the hope that oil might be located east of the present pools.

It is well known that on the east side of the La Salle anticline the beds dip much more gradually than on the west, and that in the eastern part of the county they start to rise toward Indiana where older beds outcrop in succession. The basin bordering the La Salle anticline on the east is shallow and it is not unreasonable to expect pools of oil and gas where the sands rise above the level of salt-water saturation east of the basin, provided the dip is not regular. With these facts in mind, members of the Survey have attempted to collect all the available information bearing on the dip of the beds. The altitude of a limestone, which outcrops at various places and which is identifiable by the fossils it contains, was determined by T. E. Savage during the summer of 1915. Instrument levels were run by J. L. Rich and party to all of the wells, and available logs were secured.

After plotting the data on a map, it is found that the limestone outcrops are so scattered that they are practically useless for showing the position of the underlying beds. There is reason to believe also that the limestone does not lie perfectly parallel to the deep rocks and that its evidence might lead to an incorrect interpretation of the oil sand structure.

A study of the logs brings out the fact that the sands are "spotty" and that correlations from one hole to another are uncertain, especially where the wells are a mile or so apart. It is, therefore, impossible to state definitely whether the apparently higher position of a sand is due to its dip or to the existence of two separate beds.

In general, the presence of gas may be taken to indicate that the sand containing it lies somewhat higher than in surrounding territory. Most of the wells near Wabash River, east of the Birds pool show gas bubbling up through salt water. However, the area on the Illinois side has been fairly well tested and only two small pools have been developed. One lies in sec. 7, T. 5 N., R. 10 W.; the other, which shows gas only, is in sec. 18 of the same township.

LAWRENCE COUNTY

In 1915 only 157 wells were completed as compared with 365 in 1914. The low price of oil did not stimulate drilling in this deep-sand territory.

Considerable excitement followed the discovery, April 6, 1914, of a 3,100-barrel well on the M. J. Murphy farm sec. 5, T. 2 N., R. 11 W. (Dennison), which led to a substantial southeast addition to the productive area of the McClosky sand, at 1,835 feet. The large yields soon gave place to much lower production. During the latter part of 1914, a separated pool was located in secs. 20 and 29, T. 2 N., R. 11 W., southwest of St. Francis-

ville. The McClosky sand at this place lies at about the same depth as in the Murphy pool.

According to Mr. Tracy of the Ohio Oil Company the average daily production of Lawrence County is about 6.83 barrels per well as compared with 9.14 barrels in January, 1914. However, Lawrence County continues to be the largest producer in the State on account of its large number of sands. Only an occasional addition is made to productive territory, but many of the large farms contain considerable undrilled land and near Bridgeport several farms are yet to be drilled to the deeper sands.

The Buchanan and Bridgeport sands maintain a very good production and contain little gas; whereas the Kirkwood, which shows a considerable amount of gas, has a large initial production and declines rapidly. The Buchanan shows the encroachment of salt water in the edge wells which produce a larger amount yearly, especially in the area south of Bridgeport. Great loss is entailed in the destruction of casing by corroding waters in the Kirkwood and Bridgeport sands. At one well, center sec. 35, T. 3 N., R. 12 W. (Dennison), copperized casing was rendered useless in 20 months. However, the Lawrence County acid waters do not appear to effect as great destruction as do those of Crawford and Clark counties.

The manufacture of casing-head gasoline is assuming greater importance annually. At present about 20 plants are operating in the main fields, all but 3 being in Lawrence County. The product which is worth many thousands of dollars yearly, was wasted until the present plants came into use. The average recovery of gasoline is said to be between 1 and 2 gallons per 1000 cubic feet of casing-head gas.

Wabash County

Six wells were completed in the Allendale field in 1915 of which 5 gave a combined initial production of 328 barrels. There are now 45 producing wells in the pool. The territory has not been extended to any material extent, although a good well has been found north of the original Adam Biehl No. 1.

The Allendale pool is located on a small elongate dome with north-south axis, on the west dip of the La Salle anticline. A report on the field by J. L. Rich was published by the Survey in Bulletin 31.

WESTERN ILLINOIS

McDonough County

On March 5, 1914, a showing of 5 gallons of oil in a 425-foot well in sec. 20, T. 4 N., R. 4 W. (Lamoine), and the prospecting that followed resulted in the opening of the Colmar pool on the J. Hoing farm in the SW. ¼ NW. ¼ sec. 16 of the same township. The oil was found in a sand, later known as the Hoing sand, at a depth of 417 feet. Great excitement

followed and by the end of 1914, about 200 wells had been drilled in the Colmar district, of which 59 were dry. The initial output of the 141 producers amounted to 3,989 barrels.

The pool developed in 1914 lies on a flat part of the oil sand at the northeast side of a low well-defined dome, the top of which had produced only small showings of oil up to 1915. Roberts No. 1 near the center sec. 24, St. Marys Township, Hancock County, was located at the south end of the dome and produced 45 barrels initially. Others were drilled immediately, but all of them found salt water in the sand. In July, 1915, drilling on the Hamm farm at the apex of the dome in sec. 19, T. 4 N., R. 4 W. (Lamoine), developed wells good for 100 barrels, and this pool furnished most of the development of the year. Another small area of good production is located near Colmar in the south part of sec. 18, of the same township.

The oil sand lies at or near the base of the Niagaran limestone, known as the "second lime." It was probably deposited in depressions on the surface of the shale that underlies the limestone, and therefore the sand exists as lenses separated by areas in which the limestone lies directly on the shale with no intervening sand. No direct connection is apparent between the Hoing pool where the sand lies 90 feet above sea level and the Hamm pool in which the sand is 70 feet higher. Likewise the pool at the town of Colmar lies on the north side of the dome and probably has no direct connection in the sand with either of the other pools.

In November, 1915, 106 wells belonging to the Ohio Oil Company yielded about 3,450 barrels per week. Most of this oil was produced by the comparatively small number of wells in the new Hamm pool.

In 1915, 130 wells were drilled in McDonough County having an initial production of 2,592 barrels per day, and 32 were dry. The area was originally recommended in a report by H. Hinds of the U. S. Geological Survey in cooperation with the State Geological Survey, and a later report on the field was published in Bulletin 31 of the State Survey.

The dome in the oil sand conforms very closely in position and amount to the arching of coal No. 2 which was mapped before any oil wells had been drilled.

Hancock County

Section 13, T. 4 N., R. 5 W. (St. Marys), has not been thoroughly prospected. It is impossible to state whether or not the Hoing sand is present in the section, but if the lens of sand which extends in an east-west direction on the J. B. McAllister farm in the southern part of sec. 18 and northern part of sec. 19, T. 4 N., R. 4 W. (Lamoine), does continue to the west, at least the southern half of sec. 13, T. 4 N., R. 5 W. (St. Marys), would bear testing.

Schuyler County

WILDCAT TESTS IN 1915

Considerable wildcat drilling was undertaken during 1915 in Schuyler County, for the most part confined to domes to which attention had been called by the Survey in Bulletin 31, issued in August. The structure of the county was worked out during 1914 by methods similar to those previously employed in the Colmar area. Several areas were described in which the beds lie higher than in the surrounding territory. Being fully cognizant of the "spotty" nature of the Hoing sand and of the possibility and even the probability that it is absent over most of the county, the Survey prefaced its description of the structural features by the following paragraph which is quoted from Bulletin 31:

"Because the oil-producing bed is lenticular and is absent over considerable areas, the selection of favorable locations for drilling is fraught with more than the usual element of uncertainty. There is little doubt that in some of the areas described below, the sand is absent, and in this event there will be no accumulation of oil despite the favorable geological structure. It is hoped that the sand is present in at least a few of the areas listed below so that the combination of porous beds with favorable dips may be tested. The presence or absence of the sand cannot be predicted in advance of the drill."

The Scott Mill dome was well tested by the Ohio Oil Company, and no sand was found at the Hoing horizon. Similar results followed drilling in the dome southwest of Rushville. The same company drilled a well a short distance from the Huntsville terrace without finding any sand, and it is probable that no sand is present in the terrace itself.

In sec. 9 of the Buena Vista dome the Indian Refining Company found a good showing of oil in the upper part of the "second line." However, the Hoing sand was absent.

South of the Frederick terrace the Ohio Oil Company drilled a hole where the beds are 20 feet lower than on the top of the terrace. They found no Hoing sand, but considerable gas and a large amount of salt water in the second lime. If the sand had been present in this well, another test ¾ mile northwest would be advisable but it is probable that no sand is present on the terrace proper. The well drilled by this company 2 miles northeast of Frederick is located in a basin which would be regarded unfavorable.

The Macomb Oil and Gas Company in their Caldwell No. 1, NE. ¼ NE. ¼ sec. 11, T. 3 N., R. 2 W. (Littleton), reports 18 feet of white sand, saturated with salt water at the Hoing horizon. The sand was found at a depth of 585 feet. The same sandstone, likewise saturated with salt water, was found at 692 feet in the Bovey well of the Macomb Oil and Gas Company, SE. ¼ SW. ¼ sec. 14 of the same township. Similarly, Elting and others in Dean No. 1, NE. ¼ NE. ¼ sec. 20, T. 3 N., R. 1 W. (Oakland), report 10 feet of Hoing sand with water and a showing of oil at 700 feet.

C. E. Hites and Company completed a well 40 rods from the north line and 60 rods from the east line of sec. 13, T. 3 N., R. 2 W. (Littleton), where the beds are somewhat higher than in the wells mentioned immediately above. At a 648-foot depth, the Hoing sand was found, and in the upper 3 feet a good showing of oil was noted. As the well was deepened, however, salt water came in and filled the hole 350 feet. It was impossible by bailing to lower the water more than 150 feet, but when the bailer was run, a good showing of oil was found.

The presence of the sand in the wells near Littleton and the shows of oil that have been noted are favorable indications for the northeastern part of Schuyler County. The last well mentioned is located near the highest part of a low dome in which coal No. 2 is 600 feet above sea level. The fact that the sand is saturated with salt water makes it seem rather doubtful that the sand rises enough in the immediate vicinity to hold a commercial amount of oil above the water. A considerable area in Littleton and Oakland townships probably contains the Hoing sand. The surface outcrops of rocks by which the structure can be determined are scarce. The beds lie higher in the dome mentioned above—namely, 3 miles east and 1 mile north of Littleton, as pointed out in Bulletin 31, than anywhere else in Littleton and Oakland townships where measurements were possible.

SUMMARY OF TESTS IN SCHUYLER COUNTY

During 1915, 7 wells were drilled on domes and terraces in Schuyler County; ten others were drilled without regard to structure or at least so far from favorable features that they can not be regarded as tests except as to the presence or absence of the sand. Of the 7 wells drilled on domes and terraces, 6 found no sand at the Hoing horizon, a probability to which attention was called in Bulletin 31. Despite the absence of sand, the Indian Refining Company, in sec. 9, T. 2 N., R. 2 W. (Buena Vista), found a splendid show of oil in the "second lime," near the top of the Buena Vista dome. The only well located near the top of the Littleton dome—C. E. Hites and Company, NE. ¼ NE. ¼ sec. 13, T. 3 N., R. 2 W. (Littleton)—found a good show of oil in the Hoing sand which contains salt water.

SOUTH-CENTRAL ILLINOIS

Macoupin County

STAUNTON OIL AND GAS FIELD

In 1914 the Illinois Geological Survey described a dome northwest of Staunton, Macoupin County.[2] The existence of the dome was determined by the position of coal No. 6 in coal test holes drilled by the C. & N. W. R. R. Co. It was later described in greater detail by Wallace Lee of the U. S.

[2]Blatchley, Raymond S., Oil and gas in Bond, Macoupin, and Montgomery counties: Ill. State Geol. Survey Bull. 28, 1914. Also Kay, F. H., Coal resources of District VII: Illinois Coal Mining Investigations Bull. 11, 1915.

Geological Survey in cooperation with the Illinois Survey.[3] Early in 1915, Miller Bros., of Staunton, drilled a well near the highest part of the dome in the SE. cor SW. ¼ SW. ¼ sec. 14, T. 7 N., R. 7 W. (Dorchester), and brought in a large production of gas from a sand at 441 feet. Prospecting was stimulated, and before the end of the year a number of wells were drilled in the area. In the N. ½ sec. 23, and the S. ½ sec. 14, 7 gas wells were completed, the largest of which (Daniel Groves No. 1), is reported to have a capacity of 20,000,000 cu. ft. per day.

One mile northwest of the principal gas area, the Ohio Oil Co. drilled G. W. Groves No. 1 in the NE. cor. SE. ¼ NW. ¼ sec. 15, T. 7 N., R. 7 W., and at 461 feet reached a sand that produced about 2,000,000 cu. ft. of gas per day. At 480 feet a show of black oil was found, and at 565 a good show of green oil was developed. Salt water came in at the same time. About 1 mile southeast of the main gas wells the Miller Bros. completed a 5-barrel oil well at the center of sec. 24, T. 7 N., R. 7 W. The sand lies at 442 feet. In the SE. ¼ SW. ¼ sec. 24, Fleeger and Lamberton discovered gas at 427 with a reported flow of about 700,000 cu. ft. per day.

The large gas wells are located on the top of the dome, where the beds lie from 40 to 60 feet higher than in the surrounding area. In the Isaacs well, NW. ¼ SW. ¼ sec. 12, T. 7 N., R. 7 W., coal No. 6 is almost as high as it is in the dome 1½ miles southwest. However, without further drilling it is impossible to state definitely whether or not the sands are high all the way between the gas area and the Isaacs well. The lower position of the coal and sands northwest and southeast of the gas wells, together with the altitude of the coal southwest and northeast of the present main field, make it seem probable that the dome is longer northeast-southwest than in the opposite direction.

The producing sands lie in the basal part of the "Coal Measures," the upper one occupying about the position of coal No. 2. No single sandstone can be traced throughout the area; in other words, the sands were probably deposited in channels whose streams eroded away the beds such as the coals normally in the bottom part of the "Coal Measures." Two such lenses are represented in the larger gas wells, the top of the first being from 195 to 215 feet below the top of coal No. 6, whereas in H. Woolridge No. 1, SW. ¼ SE. ¼ sec. 14, T. 7 N., R. 7 W., no sand was found at the upper horizon, but 255 feet below coal No. 6 a good flow of gas was tapped in a lower lens.

This lower sand corresponds in position with the sand from which oil is obtained in the Miller oil well at the center of sec. 24, T. 7 N., R. 7 W. Whether or not the sand is continuous between the two wells must be decided by the drill. It is probable that the sand 233 feet below the coal in the gas well, NW. ¼ NE. ¼ sec. 23, T. 7 N., R. 7 W., represents a lens intermediate between the two mentioned above.

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[3]Lee, Wallace, Oil and Gas in Gillespie and Mt. Olive quadrangles: Ill. State Geol. Survey Bull. 31, p. 101, 1915.

Half-way between the oil well and the main gas field, the upper sand lies 35 feet lower than at the gas wells, and in A. Schnaare No. 1, NE. ¼ SE. ¼ sec. 23, T. 7 N., R. 7 W., only a show of gas was found, although the sand is 20 feet thick. The well was continued to 610 feet and at 605 feet, or 330 feet below coal No. 6, salt water was tapped. The top of the gas-producing sand in E. D. Wilder No. 2, SE. ¼ SW. ¼ sec. 24, T. 7 N., R. 7 W. is 222 feet below coal No. 6 and may be the intermediate lens between the main gas sand and the oil-producing sand in L. Schnaare No. 1, center sec. 24. However, the sands vary greatly in thickness, and it is likely that in places they are connected.

In his report on the Gillespie and Mt. Olive quadrangles, Wallace Lee[4] calls attention to 3 productive lenses of sand in the Carlinville field, the upper one about 200 feet below coal No. 6, the second 20 or 25 feet lower, and the main horizon 15 to 25 feet below the second. In position, the Staunton sands agree in general with those at Carlinville, although it must be understood that laterally at any given horizon shale exists here and there in place of sand, and no one sand is continuous.

In G. W. Groves No. 1 in the SE. ¼ NW. ¼ sec. 15, T. 7 N., R. 7 W., the upper sand, at 461 feet, lies 55 feet lower than at the wells in the south part of sec. 14, a fact that is corroborated by the position of the coal which shows the same amount of dip. Two million cubic feet of gas per day and a strong show of black oil, together with salt water, were found in the upper sand, whereas a good showing of light-green oil was found in a sand at 565 feet, 302 feet below the coal. Only one other well, A. Schnaare No. 1, NE. ¼ SE. ¼ sec. 23, T. 7 N., R. 7 W., has tested this deep sand near the top of the dome. In this well a salt sand in approximately the same position was reached at 605 feet.

According to available data it would seem reasonable to expect some extension of the main gas-producing area on all sides of the top of the dome. It would seem well at first to test the remainder of sec. 14, T. 7 N., R. 7 W., in a general northeast direction from the present wells. The SE. ¼ sec. 15 should be tested to determine the possibility of securing commercial gas for some distance down the dip toward G. W. Groves No. 1. The show of oil in the Groves sands encourages the belief that higher up the dip, above the salt water, some oil may have accumulated.

The structure appears favorable in the northwest part of sec. 24 and the southwest part of sec. 13, T. 7 N., R. 7 W., but only the drill can determine whether or not sand is present. If the sand is continuous from the gas wells in secs. 23 and 14 to the oil well at the center of sec. 24, a good deal of productive territory should be developed.

Drilling for oil should be done, location by location, away from the Schnaare oil well, cen. sec. 24, T. 7 N., R. 7 W., and unless shallower sands

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[4]Lee, Wallace, Oil and Gas in Gillespie and Mt. Olive quadrangles: Ill. State Geol. Survey Bull. 31, pp. 71-107, 1915.

produce, all holes should be continued to a depth of at least 270 feet below coal No. 6. If the operator desires to test the horizon that produced a show of green oil in the G. W. Groves well, he should drill about 330 feet below coal No. 6.

Coal test holes near the center of sec. 10, T. 7 N., R. 7 W. (Dorchester), show that the coal lies almost 350 feet above sea level, whereas in the NE. cor. sec. 10 it is at least 20 feet lower. One mile south, at the G. W. Groves well, SE. ¼ NW. ¼ sec. 15, T. 7 N., R. 7 W., the coal is 312 feet above sea level. At the center of sec. 9, its altitude is 337 feet.

The gas and oil at the Groves well, and the higher altitude of the coals near the center of sec. 10 would render worth while a test at about the center of sec. 10. The sands may be absent, but no prediction can be made in advance of the drill.

Table 30 furnishes such information as is available regarding the Staunton wells. Very few complete logs have been preserved, and consequently one who attempts correlations that are very important as regards the sands, is decidedly handicapped.

SPANISH NEEDLE CREEK DOME

In Mr. Lee's report included in Bulletin 31, he recommended the Spanish Needle Creek dome, which lies chiefly in the western part of sec. 21, T. 9 N., R. 7 W. (Honey Point). The existence of the dome was determined from the position of a limestone that outcrops in the area.

The first well at the SE. cor. SW. ¼ NW. ¼ sec. 21, T. 9 N., R. 7 W., reached a good flow of gas at 380 feet in a sand that continued to the bottom of the well at 415 feet. According to Mr. Thomas Rinaker, of Carlinville, the well has a capacity of 2,000,000 cu. ft. of gas per day. A second well was drilled near the cen. E. ½ SW. ¼ sec. 21, where the limestone is about 20 feet higher than at the first well. A good flow of gas was struck at 364 but salt water came in at 370 and drowned the gas. The interval between the coal and sand in the first well is 205 feet, whereas in No. 2 it is only 177 feet, if the meagre records are correct. This may signify that the sand in No. 2 is a higher bed not present in No. 1, and that another sand lies lower in No. 2. In view of the fact that the main horizon at the Carlinville field lies 40 or 50 feet below the upper bench of coal No. 2, it would be well to drill at least 250 feet below coal No. 6 in any attempt to test the area.

In case salt water is found in the upper sand, it would be worth while to case it off for the purpose of testing the lower sands.

In the old Carlinville field no wells were added in 1915. Three producers, with a total initial production of 15 barrels, were drilled in 1914.

CLINTON COUNTY

The Carlyle pool, discovered in 1911, was quickly defined and only a small amount of inside drilling remains to be done.

TABLE 30.—*Data concerning wells and coal tests in vicinity of Staunton*

Location				Operating Co.	Farm and well number	Surf. elev.[a]	Coal No. 6		Sands		Interval be-tween top of sand and top of coal No. 6	Interval be-tween top of coal No. 6 and bottom of hole	Total depth of hole	Production	Remarks
Part of sec.	Sec.	T. N.	R. W.				Depth to top	Elev. above sea	Depth to top	Elev. above sea level					
						Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*		
NW NW NW....	5	7	6	Superior Coal Co.	Coal test No. 2	634	331	303	...	...	...	...	342	....	
SE SW SW......	7	7	6	do	do No. 6	623	289	334	...	...	...	...	298	....	
SW SW NW.....	9	7	7	Ohio Oil Co.	F. Stamme No. 1	646	...	...	...	...	...	...	592	Dry	
Center	9	7	7	Superior Coal Co.	Coal test No. 18	645[b]	309	336	...	...	...	...	317	....	
NW SE	10	7	7	do	do No. 17	645	297	348	...	...	...	...	305	....	
NW SE	10	7	7	do	do No. 22	644	306	338	...	...	...	...	405	....	500′ south of well No. 17
NE cor	10	7	7	do	do No. 7	639	310	329	...	...	...	...	319		
NW SW	12	7	7	Ohio Oil Co.	C. C. Isaacs No. 1	634	289	345	502	132	213	222	511	Dry	Salt water sand
Cen SE SE SE...	13	7	7	Snowden Bros.	C. Schmutzler No. 1	551	230	321	...	...	...	430	660	Dry	
SE SW SW......	14	7	7	Miller Oil Co.	Daniel Groves No. 1	612	245	367	441	171	196	220	465		
SE SE SW.......	14	7	7	do	do No. 3	611	248	363	464	147	216	252	500	Gas	
Near cen SW SE	14	7	7	Fleeger & Lamberton	A. Woolridge No. 1	613	?257	356	512	101	255	268	525	Gas	
Cen N½ SW.....	14	7	7	do	H. Woolridge No. 1	611	?247	364	467	144	220	268	515	Gas	1st sand dry; gas in 2nd
NE SE NW......	15	7	7	Ohio Oil Co.	G. W. Groves No. 1	575	263	312	Top 461	114	...	...	...	Gas	2,200,000 cu. ft. in upper sand
									Gas 463	112	198	...	...	Oil	showing black in upper sand
									Oil 480	95	...	...	...	Oil	showing green in lower sand
NE NW	19	7	6	Miller Oil Co.	H. Adler No. 1	553	200	353	...	...	...	349	549	Dry	
Cen NW NE.....	21	7	7	Wm. Bell & Slattery	A. Bauer No. 1	588	248	340	496	92	248	323	571	Dry	
NE SE NW......	22	7	7	Superior Coal Co.	Coal test No. 8	609	276	333	...	...	...	...	283		

Cen NW NW.....	23	7	7	Miller Oil Co.	A. Fletcher No. 1	608	260	348	470	138	210	235	495	Gas	
NW NE NW.....	23	7	7	do	Daniel Groves No. 2	613	?247	366	Gas 442 460 488	171 153 125	195 213 241	... 253 ...	... 500 ...	Gas	
Cen NW NE.....	23	7	7	do	H. Woolridge No. 1	609	256	353	489	120	233	249	505	Gas	
NE NW NE.....	23	7	7	Superior Coal Co.	Coal test No. 11	609	250	359	...	...	...	...	258	....	
NE NE SW......	23	7	7	Ibbetson, Rinaker & Co.	E. G. Wilder No. 1	601	273	328	...	...	...	237	510	Dry	No salt water
NE NE SE.......	23	7	7	Miller Oil Co.	A. G. Schnaare No. 1.	600	270	330	465	135	195	340	610	Dry	Show of gas at 475
NE SE NW......	24	7	7	Miller & Bachelor Bros.	L. Schnaare No. 1	531	200	331	445	86	245	266	466	Oil	5 bbls. of black oil initial production
SW NW SE.....	24	7	7	do	do No. 2	...	...	...	...	...	...	...	...		
NE SE SW......	24	7	7	Fleeger	E. D. Wilder No. 1	531	202	329	424	107	222	242	444	Gas	Show of oil and water at 444
Cen SE SE.......	25	7	7	Old local mine	....	552	202	340	...	...	...	...	220		
Cen SW SE......	25	7	7	Miller Oil Co.	D. Funderburk No. 2	599	260	339	510	89	250	278	538	Dry	
Cen S line SW SE	25	7	7	do	do No. 1	533	195	338	445	88	250	476	671	Dry	Oil showing 7-foot at 405
NW SW	25	7	7	do	N. Smith No. 1	532	195	337	426	106	231	279	474	Dry	
NW SW	26	7	7	Superior Coal Co.	Coal test No. 10	589	242	347	...	...	...	...	249	....	
NE NE NE......	27	7	7	J. B. Nay	C. Bruhn No. 1	600	265	335	520	80	255	260	525	Dry	Salt water
SW SW SE......	28	7	7	Superior Coal Co.	Coal test No. 9	590	242	348	...	...	...	...	249	....	
NW SW	30	7	6	Miller Oil Co.	Old well, 1907	604	...	...	517	87	...	...	...	....	
NE NW	30	7	6	Consolidated Coal Co.	Mine No. 14	616	275	341	...	...	...	...	292	....	
NW SW SW.....	32	8	7	M. P. Colt, A. S. Hunt, et al.	Weidner No. 1	671	270	401	...	...	...	330	600	Dry	
SE SW NW......	21	9	7	Miller Oil Co.	A. Taylor No. 1	562	175	387	380	182	205	240	415	Gas	
SE NE SW......	21	9	7	do	do No. 2	565	187	378	364	201	177	183	370	Dry	
NW SW SW.....	29	9	7	J. D. Hurd	Coal test	625	260	365	...	...	...	...	351	....	
NE SE	28	9	7	Impromptu Explor. Co.	Geo. Hammon No. 1	638	...	...	509	129	...	...	515	Dry	Salt water; gas at 509

[a]Surface elevations were determined by transit and stadia unless otherwise stated.
[b]Estimated.

Salt water is becoming more and more troublesome, especially at the edges of the field. A few of the inside wells, such as Smith No. 1, No. 6. and No. 28, produce salt water only and require constant pumping in order to keep the water out of adjacent wells. In November 1915 the 3 wells mentioned were producing 100 barrels of water per 24 hours. The Hempen farm at the southwest end and the Deter lease at the northeast end show increasing amounts of water.

The field shows the normal decline in production and the encroachment of salt water is only natural. The field, though small in area, has been very valuable and should continue to produce commercially for several years.

At the close of the year 1915 the Frogtown Oil and Gas Company brought in a small well on sec. 12, T. 2 N., R. 4 W. (Breese), about 4 miles west of the Carlyle field. The well will probably not be pumped until other drilling is completed. The Ohio Oil Company has made 3 locations nearby, and the possibility of a new pool will soon be ascertained.

Marion County

At the close of 1914, 118 wells were productive in the Sandoval field. Five were added in 1915 with a total initial production of 270 barrels, and 1 dry hole was drilled. At the end of 1915, 81 wells on 17 different farms and owned by 7 companies exclusive of the Ohio Oil Company, were producing 800 barrels daily or an average of nearly 10 barrels each. On the farms mentioned there are only about 10 undrilled locations with an estimated settled production of 45 or 50 barrels.

The daily production of the field is about 1000 barrels, which is an extremely good yield for a field of its age. In 1911, 66 wells produced 1,800 barrels, an average of 27.2 barrels per well. Its decline to about 9.8 barrels per well for 1915 is a better record than that of most of the Lawrence County sands.

MISCELLANEOUS DRILLING

During 1914 dry holes were drilled near Sorento, Bond County; Mahomet, Champaign County; Ava, Jackson County; Staunton, Macoupin County; Collinsville, Madison County; Ohlman and Nokomis, Montgomery County; Cottage Grove, Saline County; Birmingham, Brooklyn, and Camden, Schuyler County; Mode, Shelby County; and Allerton, Vermilion County.

In 1915 unsuccessful tests were drilled near Steelville, Randolph County; Carlinville, Macoupin County; Xenia, Clay County; Heyworth, McLean County; Aledo, Mercer County; Irishtown, Clinton County; Ava, Jackson County; Charleston, Coles County; Kansas, Edgar County; Tennessee, McDonough County; Lima, Adams County; Litchfield, Montgomery County; Plumhill, Washington County; St. Marys, Hancock County; Golden, Adams County; West Salem, Edwards County; Butler, Montgomery County; Belleville, St. Clair County; and Equality, Gallatin County.

At the close of 1915 wildcat wells were drilling on sec. 31, T. 8 N. R. 7 E. (Eldorado), Saline County; in sec. 21, T. 1 N., R. 4 W. (Pea Ridge), and sec. 5, T. 1 N., R. 3 W. (Missouri), Brown County; sec. 13, T. 6 N., R. 2 E. (Otego), Fayette County; sec. 11, T. 4 N., R. 3 W. (Mills), and sec. 29, T. 6 N., R. 11 W. (Mulberry Grove), Bond County.

CEMENTING PROCESS AS PRACTICED IN ILLINOIS

The use of cement for excluding salt water from oil wells has been developed to considerable extent in different fields, especially in California. A description of the process as practiced in that state was published as Technical Paper No. 32 of the U. S. Bureau of Mines. The authors are Ralph Arnold and W. R. Garfias.

A somewhat different method has been developed by Mr. W. W. McDonald, of the Ohio Oil Company, for the Illinois fields, and its use has been attended with such success that it is believed advisable to describe the process for the use of the oil fraternity. For all of the details the Survey is indebted to Mr. McDonald.

The process is adapted to completed wells which have been drilled too deep or wells in which the shot has shattered the sand down into the salt water, and has permitted the water to drown the oil, though not to flow from the well.

A string of tubing, closed with a wooden plug, is lowered to the bottom of the oil pay. The plug is used to keep the oil from entering the tubing; it is knocked out after the tubing is in place by filling the tubing with water and striking the upper end, or if necessary by use of sucker rods. The tubing is left open, and water (either fresh or salt) is pumped down the tubing. After pumping has continued 15 or 20 minutes, dry cement is introduced into the tubing a handful at a time and pumping is continued as at first. This process is continued until the water backs up in the well very materially, which means that the pores in the salt sand have been closed.

It should be remembered, however, that sands above the water sand and below the casing may take water, and prevent a marked rise in the level of water even though the shattered salt sand is cemented. No more cement should be introduced than would fill the cavity up to the bottom of the oil sand. Ordinarily not more than three sacks of cement are required and it should be put into the well not faster than 1 sack per hour.

When sufficient cement is in place, a small stream of water is run into the tubing so that the level of water in the well will be maintained above normal, and a downward pressure be secured thereby. Unless this is done the water pressure from the sands into the well will force the cement out of the pores before it sets. The water level in the well is kept above normal for a period of 7 days to allow ample time for the cement to harden.

The well is then pumped and if the work has been properly done, no further trouble follows. The method has been used with splendid results by the Ohio Oil Company, and is coming into general use in the Illinois fields.

NEW FIELDS FOR CASING-HEAD GASOLINE TESTS

The extraction of gasoline from casing-head gas has been developed extensively in the main fields, but it is believed that such pools as Carlyle and Sandoval, where considerable quantities of gas exist with the oil, should be tested for possible gasoline production.

Chemical tests should first be made in order to determine the amount of gasoline-producing constituents in the gas that issues with the oil. If the chemical tests prove encouraging; that is, if the absorption of the gas in claroline oil or in alcohol is above 30 per cent,[5] field tests should be made with a portable outfit. Gas, closely associated with a high grade oil as at Carlyle and Sandoval, should contain an important per cent of the lighter constituents. The only safe procedure, however, is to have thorough preliminary tests made, to insure against failure.

In this connection, attention naturally turns to the Staunton field. The supply of gas in this field is great, and if the production were of the "wet" variety a new industry might be developed. The following points should be considered:

1. A sample of gas from D. Groves No. 1 on top of the dome, producing from the upper sand, appears to be low in gasoline content. This is the only sample analyzed by the Survey. The gas at this well does not seem to be closely associated with oil; however, when it is considered that there are three different lenses of sand producing in different parts of the field, that oil is known to be present in at least one of them, as shown by the Miller oil well, cen. sec. 24, T. 7 N., R. 7 W. (Dorchester), and that the different lenses may be connected here and there, it is obvious that samples from one well are not in any sense representative of the field. At least chemical tests should be made of each well's product. Especially is this true of such wells as the E. D. Wilder No. 1, SE. ¼ SW. ¼ sec. 24, T. 7 N., R. 7 W. (Dorchester), in which the gas comes from a sand that is probably connected with the oil sand in the Miller oil well.

2. The oil in the Staunton field contains a lower per cent of the lighter constituents than the oils of Clinton, Marion, Lawrence, and Crawford counties, and gas associated with the oil at Staunton would probably not contain so large a per cent of gasoline as is present in the gas of the counties mentioned. The notable supply of gas, however, renders thorough testing highly desirable.

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[5]Burrell, G. A., Seibert, F. M., and Oberfell, C. C., The condensation of gasoline from natural gas: U. S. Bureau of Mines Bull. 88, 1915.

SUMMARY TABLES

The following tables show the oil development in Illinois during 1914 and 1915. The figures have been compiled from the *Oil City Derrick* and the *Oil and Gas Journal.*

TABLE 31.—*Monthly record of wells drilled in Illinois in 1914 to 1915*

Month	Completed		New production		Dry holes		Average initial production		Abandoned wells		Gas wells	
	1914	1915	1914	1915	1914	1915	1914	1915	1914	1915	1914	1915
			Bbls.	*Bbls.*			*Bbls.*	*Bbls.*				
January ...	148	47	2,925	975	15	14	21.9	29.6	15	31	7	2
February ..	135	35	3,459	640	28	11	32.3	26.6	2	10	4	1
March	136	53	2,443	1,478	18	11	20.7	35.1	6	8	2	1
April	192	54	4,852	1,254	41	10	32.1	28.5	1	9	2	1
May	154	53	5,552	953	35	19	46.6	28.0	2	7	3	1
June	180	54	6,542	1,219	52	16	51.1	32.1	5	11	5	2
July	139	64	3 801	1,356	36	17	36.9	28.8	16	13	3	1
August	142	71	2,807	1,367	39	18	27.2	25.8	2	18	3	1
September .	139	66	2,925	1,236	28	16	26.3	24.7	12	12	0	1
October ...	98	79	1,517	1,263	27	19	21.4	21.0	13	18	2	4
November .	63	84	1,056	1,051	14	25	21.6	17.8	11	12	1	1
December .	57	96	1,358	1,263	22	21	38.8	16.8	10	6	0	2
Total	1,583	756	45,237	14,055	335	197			95	155	32	18

TABLE 32.—*County record of wells drilled in Illinois in 1914 and 1915*

1914

County	Completed	New production	Dry	Gas	Abandoned
		Bbls.			
Clark	222	1,581	62	2	5
Cumberland	25	141	2	0	0
Crawford	707	8,613	136	28	48
Lawrence	365	24,263	69	2	42
Marion	7	70	1	0	0
Clinton	4	20	2	0	0
Wabash	12	345	5	0	0
Macoupin	5	15	2	0	0
Coles	21	172	5	0	0
Madison	1	0	1	0	0
Jasper	5	28	2	0	0
Union	1	0	1	0	0
McDonough	175	3,944	35	0	0
Saline	1	0	1	0	0
Bond	2	0	2	0	0
Schuyler	5	0	5	0	0
Hancock	20	45	19	0	0

TABLE 32.—*County record of wells drilled in Illinois in 1914 and 1915*—Concluded

1914

County	Completed	New production	Dry	Gas	Abandoned
Shelby	1	0	1	0	0
Franklin	1	0	1	0	0
Champaign	1	0	1	0	0
Montgomery	2	0	2	0	0
Total	1,583	45,237	355	32	95

1915

County	Completed	New production	Dry	Gas	Abandoned
Clark	141	1,914	33	1	3
Cumberland	44	810	4	2	0
Crawford	215	1,766	55	8	87
Lawrence	157	6,329	27	1	63
Coles	3	35	1	0	0
Marion	6	270	1	0	0
Clinton	2	0	2	0	0
Wabash	6	328	1	0	2
McDonough	130	2,592	32	0	0
Hancock	9	0	9	0	0
Schuyler	17	0	17	0	0
Macoupin	10	5	3	6	0
Montgomery	3	0	3	0	0
Edgar	4	6	1	0	0
Jackson	1	0	1	0	0
Adams	2	0	2	0	0
Washington	1	0	1	0	0
Edwards	1	0	1	0	0
Madison	1	0	1	0	0
St. Clair	2	0	2	0	0
Randolph	1	0	1	0	0
Total	756	14 055	197	18	155

The total number of wells drilled to Jan. 1, 1916, was 23,854 of which 4,316 or 18 per cent were dry.

GEOLOGIC STRUCTURE OF CANTON AND AVON QUADRANGLES

By T. E. Savage

(In cooperation with United States Geological Survey)

OUTLINE

ILLUSTRATIONS

Introduction

It should be remembered that the geological structure is only one of the factors which control the accumulation of oil and gas into commercial deposits. In the Avon-Canton region it is doubtful if the Hoing sand exists in more than a few separated areas. The most that the geologist attempts to do is to eliminate as much of the chance as possible by selecting areas in which the beds are arched up into domes or anticlines where the accumulation will take place if the sand is present, and if the water saturation is great enough to hold the oil and gas in the upward folds. By limiting exploration to small areas, the geologist renders invaluable service, but he can by no means guarantee oil at any given location. In the present paper, it is intended simply to describe the position of the beds in the Canton-Avon quadrangles. The Survey has received a number of requests for this information, and since wells are to be drilled, it would be wise to test first the areas which have one factor—namely, favorable geological structure, determined in advance of drilling.

The field work upon which this report is based was done in 1914 as part of the regular program of the State Geological Survey in cooperation with

the United States Geological Survey. Ordinarily the present paper would constitute part of a geological folio; but in view of the wide interest and renewed activity in the oil fields of western Illinois, it is regarded best to make immediately available any information that may aid the prospector in selecting the more favorable areas for oil and gas accumulation.

Strata Penetrated in Drilling

The strata in this region are very similar to those of the Colmar area. Because of the general eastward dip, all of the formations are somewhat deeper in the territory under consideration, than in the Colmar field. Figure 6 gives a graphic representation of the relation of the strata in the two areas.

The succession of strata above the oil horizon known as the Hoing sand and the increase in the depth of this horizon from the west toward the east, in the direction of the dip in this area, may be seen from the logs of drillings given below.

A boring put down by J. E. Harris in the SW. ¼ sec. 31, T. 6 N., R. 1 E., near the town of New Philadelphia, reached the Hoing sand horizon at a depth of 651 feet as shown in the following log. The sand itself is not present. All but the upper 238 feet of this log was compiled from a study of samples that were saved from every bailer as the well was put down. The upper part was taken from the driller's record.

Log of well drilled in SW. ¼ sec. 31, T. 6 N., R. 1 E.

(See figure 6, No. 3)

	Thickness *Feet*	Depth *Feet*
Pleistocene and Recent—		
Soil and yellow clay	17	17
Sand, soft	2	19
Clay, blue	39	58
Quicksand and fine gravel (gas at 58 feet)	4	62
Gravel (water and gas)	10	72
Pennsylvanian series—		
Pottsville formation—		
Limestone (?)	14	86
Shale, blue	69	155
Mississippian series—		
Burlington limestone ("first lime")—		
Limestone, white to light gray (water)	190	345
Kinderhook shale—		
Shale, light gray to bluish	85	430
Devonian system—		
Upper Devonian (Sweetland Creek) shale—		
Shale, dark and light	155	585
Wapsipinicon limestone (top of "second lime")—		
Limestone, light gray, slight showing of oil at 610 and 635 feet	56	641

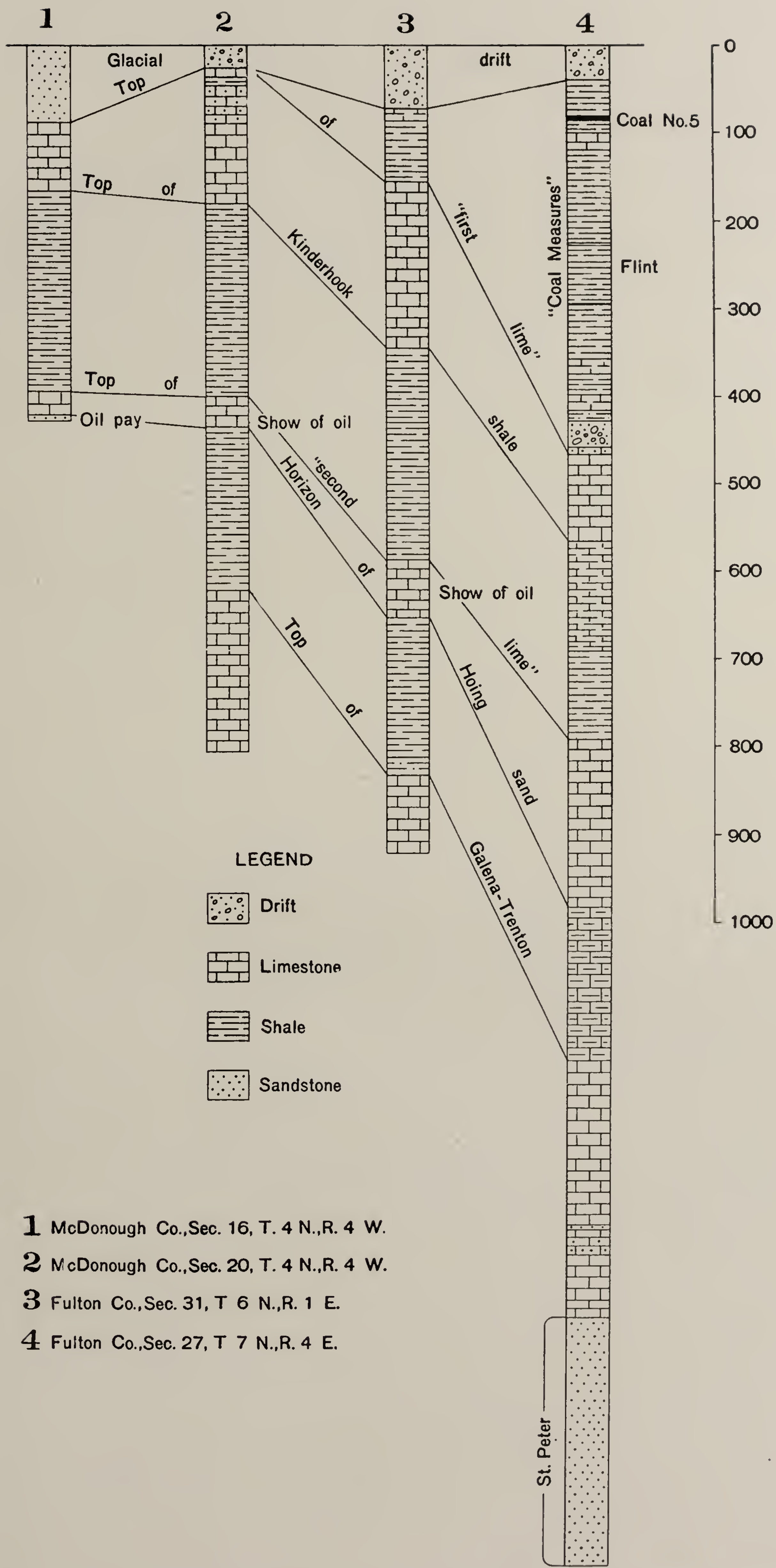


FIG. 6.—Cross-section showing relation of beds in Avon and Canton quadrangles to those of Colmar field.

Silurian system—		
Limestone, gray, magnesian	10	651
Horizon of Hoing sand		
Ordovician system—		
Maquoketa shale—		
Shale, bluish gray	160	811
Shale, gray, somewhat sandy	20	831
Galena limestone—		
Dolomite, yellowish gray	89	920

About 22 miles east of New Philadelphia a deep well at Canton, put down for water by the Parlin and Orendorff Plow Company, reached the horizon of the Hoing sand at about 980 feet, or nearly 330 feet deeper than in the well near New Philadelphia. The log of the Canton well is given below:

Log of well in SE. ¼ SE. ¼ sec 27, T. 7 N., R. 4 E.

(See figure 6, No. 4)

	Thickness *Feet*	Depth *Feet*
Pleistocene and Recent—		
Surface clay	22	22
Sand	2	24
Clay, blue	16	40
Pennsylvanian series—		
Carbondale formation—		
Shale	40	80
Coal (Springfield or No. 5)	4½	84½
Shale	15	99½
Limestone	20	119½
Shale	61	180½
"Slate"	15	195½
Shale	30	225½
Coal	1½	227
Pottsville formation—		
Clay shale	6	233
Shale	15	248
Flint	5	253
Shale	35	288
"Slate"	7	295
Coal	1	296
"Slate"	12	308
Shale	50	358
Limestone (?)	17	375
Shale	23	398
Limestone (?), blue	18	416
Shale, sandy	12	428
Sandstone and conglomerate	30	458
Sandstone	7	465

Mississippian series—		
Burlington formation ("first lime")—		
Limestone, white	100	565
Kinderhook shale—		
Shale, gray, calcareous, about	125	690
Devonian system—		
Upper Devonian shale—		
Shale, dark, with sporangites, about	101	791
Wapsipinicon limestone (top of "second lime")—		
Limestone, gray	62	853
Silurian system—		
Niagaran limestone—		
Limestone, magnesian	127	980
Horizon of Hoing sand		
Ordovician system—		
Maquoketa shale—		
Shale and limestone	175	1155
Galena-Trenton limestone—		
Limestone	186	1341
Sandstone (dolomite)	5	1346
Limestone	10	1356
Sandstone and limestone mixed	20	1376
Limestone	69	1445
St. Peter sandstone—		
Sandstone, white	282	1727

Definite figures regarding the thickness of the formations above the Hoing sand cannot be given for the entire area, since some of them were affected by erosion after having been deposited and before other beds were laid down upon them; in some places this erosion progressed to greater depths than in others.

The significance of the unconformities is shown graphically in figure 7, the unconformities being represented by the irregular contact lines between different formations. Such contact planes are simply ancient land surfaces, some of which had almost as much relief as the surface today; whereas others exhibit a relief of only a few feet.

Oil-bearing Bed

In the western Illinois oil field the producing stratum is a sandstone, known as the Hoing sand, which is locally present immediately below the Silurian limestone and above the Maquoketa shale. Sandstone is not known at this horizon in any other portion of Mississippi Valley, and in this region it is not a persistent bed but occurs in separated areas, the general direction and extent of which have not yet been determined.[1] This sandstone appears never to have been laid down over an extensive area, for many of the wells

[1]This sand was probably derived from the deeply weathered residual material that was developed on the surface of the Maquoketa shale during the long period of land conditions that prevailed in this region between the end of the Maquoketa and the beginning of Niagaran time. This residual mantle was worked over, and the sand sorted out and deposited in local depressions by the Niagaran sea when it first advanced over the region.

pass from the Niagaran limestone ("second lime") directly into the Maquoketa shale. In some places it may have been removed by erosion before the later beds were deposited. During this erosion period the Silurian strata were in some places entirely removed, so that the Devonian limestone was deposited upon the Maquoketa shale.

Relation of Accumulation to Folds in Oil-bearing Beds

In most of the productive fields of Illinois, as in Lawrence and Crawford counties, the oil occurs in the upper parts of anticlines or domes, or in

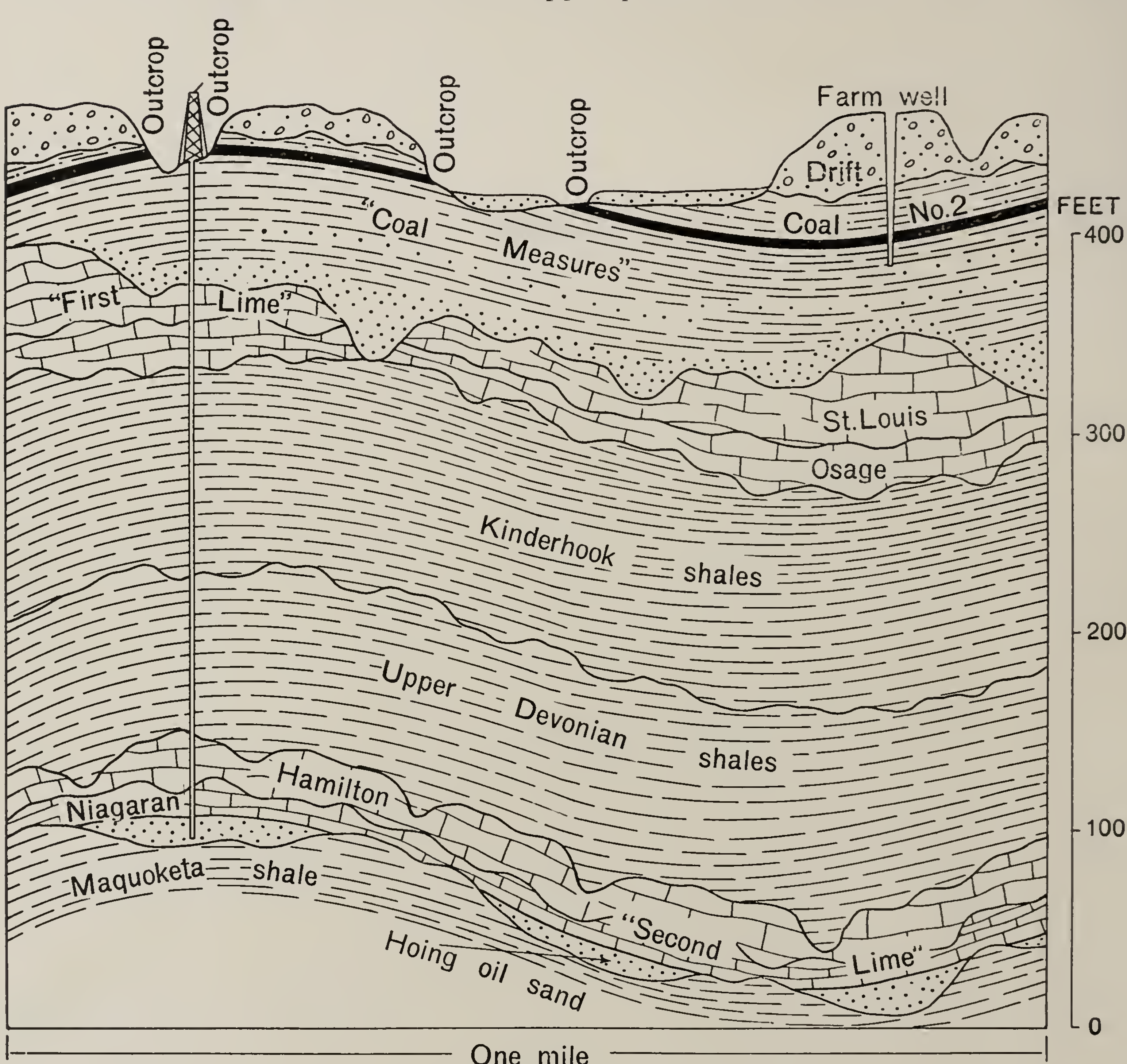
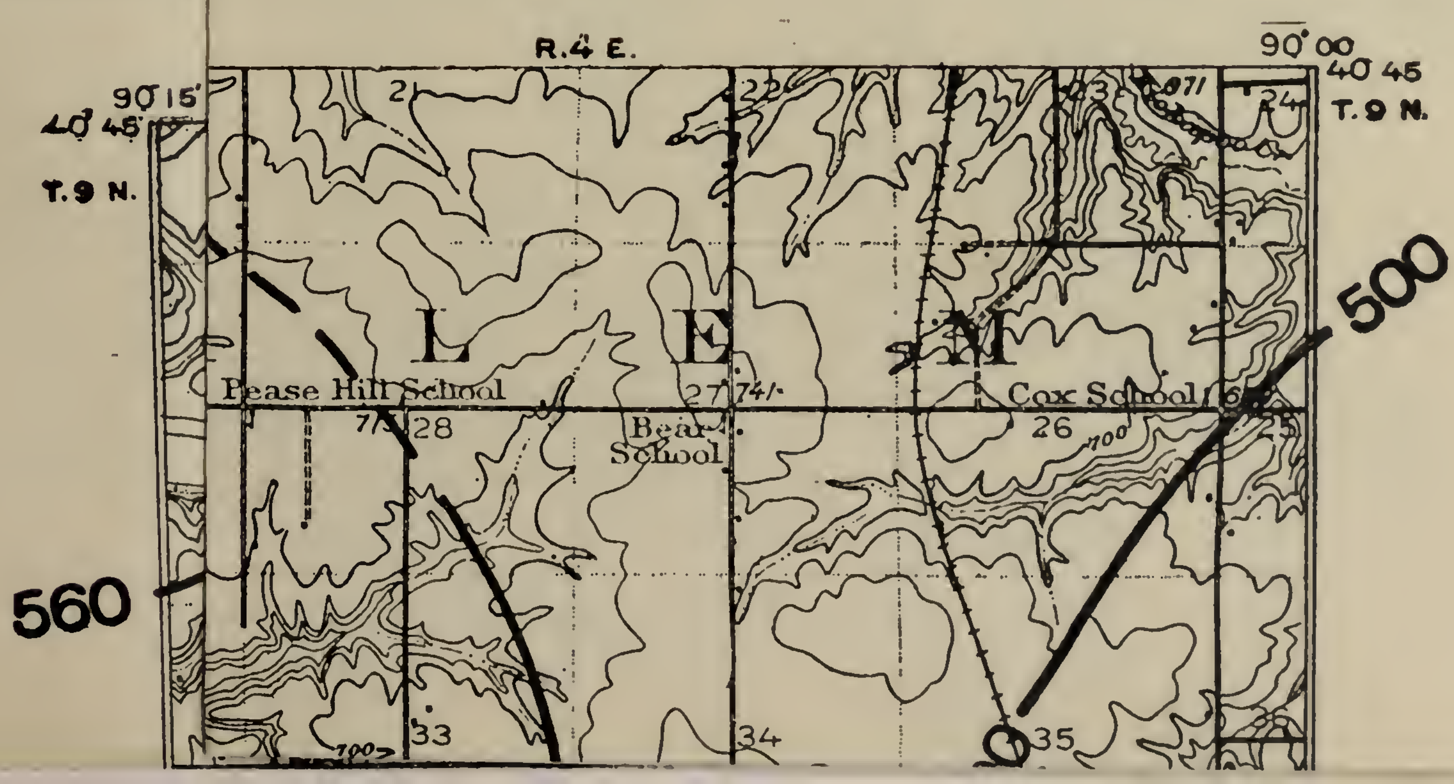


Fig. 7.—Diagram showing significance of unconformities in the Avon-Canton region.

terraces on the sides of the folds. The productive oil fields of Illinois are surrounded by a barren area in which the wells tap salt water. This is strong evidence that the water is an important factor in determining where the oil will accumulate in the sand stratum after it has been more or less folded. Where the sand is practically saturated with water (fig. 8, A), the oil generally occurs near the crest of the anticlines. Where the sand is

ILLINOIS S

BULLETIN NO. 33, PLATE II



Map showing structure of Canton quadrangle

DESCRIPTION OF MAP

The heavy black lines show the position of coal No. 2 above sea level, and are to be considered apart from the fine black lines which represent the surface of the region.

The reader is requested to imagine that all of the beds are removed down to the surface of coal No. 2, and that the southeast part of the area is flooded by water which stands 480 feet above sea level. The heavy black 480-contour line would represent the shore-line at the first stage, but if the level of the water were raised by 20-foot intervals the successive shore-lines would be represented in turn by the higher contour lines. Thus the surface of the coal 1½ miles northwest of Fairview is high and would remain above water as an island until the water level was raised to 620 feet.

The general dip of the coal and underlying beds is toward the south and east, but the irregularities represented by the curves in the contours may best be understood by a study as outlined above in connection with accompanying text.

SPECIAL NOTICE

It is impossible to predict the presence of oil in any given area. The fact that the Hoing oil sand is present at only a comparatively few places adds an additional large element of uncertainty in the western counties of Illinois.

Since in most fields the oil accumulates where the sand has been folded upward and since the downward folds or synclines are usually filled with salt water, a map which shows the position of the beds previous to drilling is very valuable. The operator can then confine his tests to territory where accumulation would take place if the other conditions are favorable. Thus one element of chance is eliminated.

only partially saturated with water the oil is found farther down the sides of the folds (fig. 8, B), and the crests may be dry. If no water is present, the oil may occur in the troughs or synclines (fig. 8, C), and the anticlines may be barren.

In western Illinois the strata have a gentle eastward dip, and the structural features consist of small folds, domes, or terraces which have been developed as small irregularities or interruptions in the general eastward slope, the crests of many of the larger anticlines or domes being only 20 or 30 to 50 feet high. The oil-bearing sandstone is present only in disconnected patches or separated lenses as is shown by the fact that the oil and water in the sandstone occur in different places at so different elevations as to preclude the possibility of any connection of the strata between them. Under these conditions the accumulation may progress in each lens independently, and the degree of saturation by oil and water determines whether the accumulation will take place at the top of the folds or in terraces lower down or in the troughs or lowest parts of the depressions.

Localities Already Tested

Although not drilled in search of oil, deep-water wells test the strata for oil and gas accumulations as effectively as wells drilled especially for oil. In Canton three deep wells put down for a water supply penetrated to a depth 600 to 700 feet or more below the horizon of the Hoing sand without finding any oil. At Cuba, a similar well, drilled to the St. Peter sandstone, encountered no oil or gas. Deep wells have also been drilled at Bushnell and at Avon, but no oil or gas was encountered. In a deep well on the J. E. Harris farm in the SW. ¼ sec. 31, T. 6 N., R. 1 E., about three miles south of the Avon quadrangle, a showing of oil was reported in the lower part of the Niagaran limestone at depths of 610 and 635 feet respectively, the latter of which is only a few feet above the horizon of the Hoing sand.

Gas in Glacial Drift

Small quantities of gas have been reported from porous beds in the glacial drift at several places in this region. In a water well near the northeast corner of sec. 22, T. 7 N., R. 2 E., gas rises in bubbles through the water every few minutes in such quantities that it can be ignited with a match. In the well drilled on the farm of J. E. Harris, the log of which has been given on a previous page, gas was encountered in beds of sand and gravel at the depths of 58 and 72 feet respectively, in such quantity as to interfere with the lights in the drilling rig. Two years after this drilling was made gas continued to rise through the water of this well at the mouth of which it could be readily ignited. Small quantities of gas have been reported in a number of other shallow water wells in this region. In all of these cases the gas was doubtless derived from the decomposition of organic

matter that was buried in the glacial drift, and it can not be expected to occur in such quantity as to be commercially important. It has no necessary connection with oil or gas accumulations in the deeper rock strata, nor is its

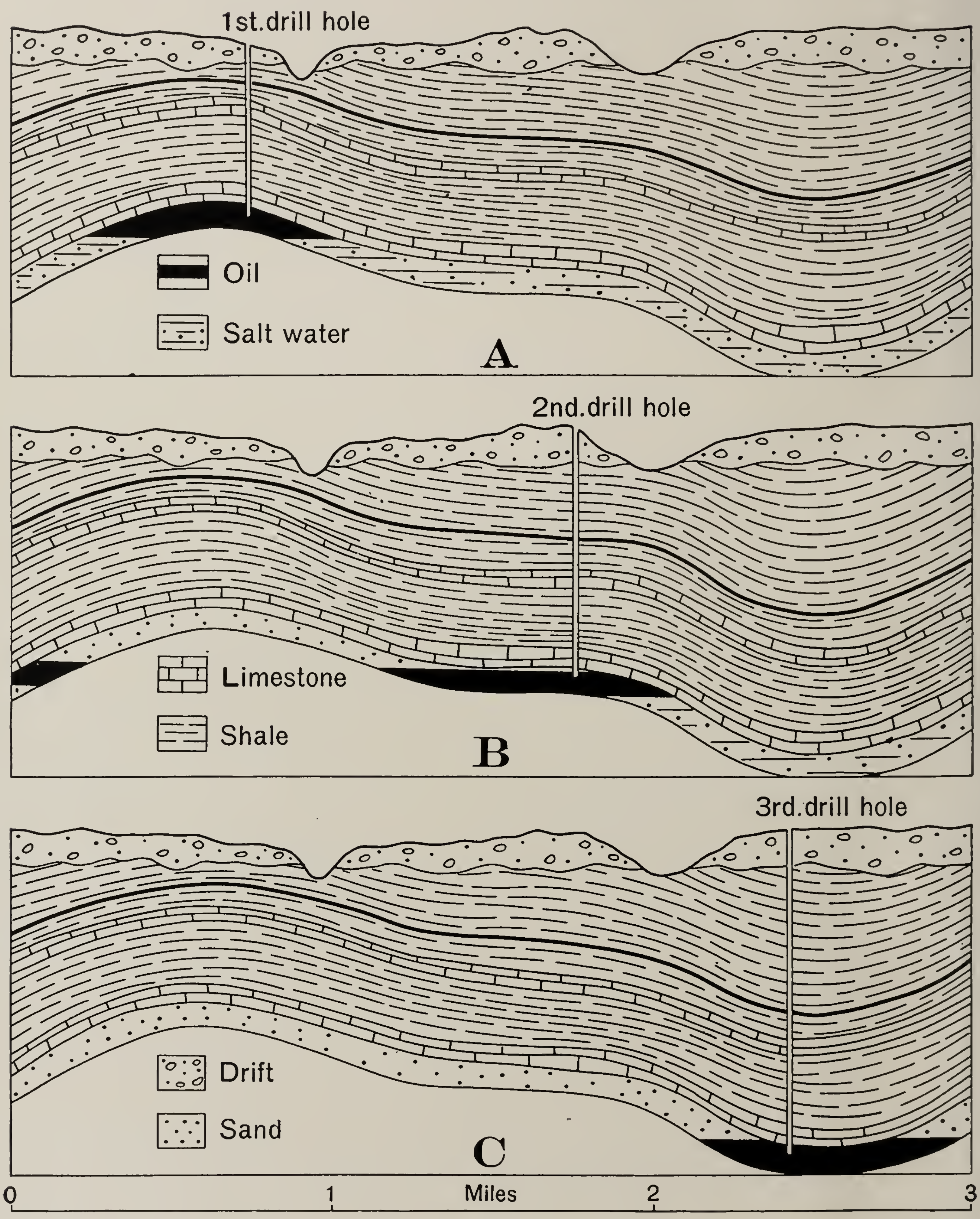


FIG. 8.—Diagram showing relation of oil accumulation to geologic structure.

presence in the beds of sand and gravel of Pleistocene age any indication that oil or gas is present in the deeper hard rock strata of the region.


R.2 E
90°15'
40 45
T.9 N.
20
21
22
29
28
27
26
School
BM 553
610
560
34
655
BM 534
London
Mills
5
4
3
QUINCY
INDIAN FORD BRIDGE
624
Swegle
Creek

Map showing structure of Avon quadrangle

DESCRIPTION OF MAP

The heavy black lines show the position of coal No. 2 above sea level, and are to be considered apart from the fine black lines which represent the surface of the region.

The reader is requested to imagine that all of the beds are removed down to the surface of coal No. 2, and that the southeast corner of the area is flooded by water which stands 520 feet above sea level. The heavy black 520-contour line would represent the shore-line at the first stage, but if the level of the water were raised by 20-foot intervals the successive shore-lines would be represented in turn by the higher contour lines. Thus the surface of the coal one mile north of Babylon is high and would remain above water as a peninsula until the water level was raised to 620 feet.

The general dip of the coal and underlying beds is toward the southeast, but the irregularities represented by the curves in the contours may best be understood by a study as outlined above.

SPECIAL NOTICE

It is impossible to predict the presence of oil in any given area. The fact that the Hoing oil sand is present at only a comparatively few places adds an additional large element of uncertainty in the western counties of Illinois.

Since in most fields the oil accumulates where the sand has been folded upward, and since the downward folds or synclines are usually filled with salt water, a map which shows the position of the beds previous to drilling is very valuable. The operator can then confine his tests to territory where accumulation would take place if the other conditions are favorable. Thus one element of chance is eliminated.

Structure of Beds

In the Colmar region farther west, the oil is found in the upper part of a dome, and in a terrace on its side. Even on this favorable structure, the sand is present only in limited areas. Consequently, any recommendations for test borings for oil in the Avon and Canton area, based on the usual structure features, must be recognized as carrying an unusual amount of uncertainty. However, since it is not possible to tell before borings are made whether the Hoing sand is present or to what extent it is saturated with water in any particular locality, if test borings are to be made, it would seem wise to proceed first on the usual assumption that the rocks will be thoroughly saturated with water, and to test first the places where the structure is favorable, as the highest parts of the anticlines and domes.

From the structure map (Pl. II) it will be seen that a broad dome is present northwest of Fairview, the highest point of which is in the NE. ¼ sec. 29, and the SE. ¼ sec. 20, T. 8 N., R. 3 E. Southwest of Farmington in secs. 10 and 11, T. 8 N., R. 4 E., there is a low arch in which the beds are somewhat higher than to the north or south.

From Fiatt a low arch extends toward the southeast corner of the Canton quadrangle. The axis passes about one-half mile north of Jones School, SW. cor. sec. 27, T. 7 N., R. 3 E., and has been traced southeast to the center of sec. 10, T. 6 N., R. 4 E.

In the northwest quarter of the Avon quadrangle (Pl. III), a low anticline in present in the SE. ¼ sec. 14, T. 8 N., R. 1 W. The beds here are somewhat higher than to the west, south, and east; but no outcrops are available toward the north, and the dip in that direction is uncertain. One mile north of Babylon in secs. 11 and the western part of 12, T. 7 N., R. 1 E., the beds are higher than in any other direction except northwest.

In a few places in the southeast quarter of the Avon quadrangle irregularities of small extent are present, but no places particularly favorable for prospecting might be mentioned.

It must be remembered that the Survey has no way of ascertaining the presence of the Hoing sand in advance of drilling and that the accompanying maps are published in the hope that they may be useful in case drilling is planned.

The structures above described in detail are comparatively mild, and may or may not reflect identical structures in the deeply buried formations.

NOTES ON BREMEN ANTICLINE—RANDOLPH COUNTY

By Fred H. Kay

OUTLINE

ILLUSTRATION

Introduction

The Bremen anticline (fig. 9) was first described in 1915 by Stuart Weller in Bulletin 31 of the Illinois State Geological Survey. Not long after its publication Kiskaddon Brothers of Oklahoma leased considerable land along the anticline and drilled a well on the William Winkleman farm in the NE. ¼ SW. ¼ sec. 23, Bremen Township. Rock outcrops nearby show that the well was located a short distance north of the axis of the anticline. Some gas was found but a large quantity of salt water drowned out the flow and the well was abandoned at a depth of about 970 feet in limestone which is probably the upper part of the "Big Lime."

A number of citizens living in the vicinity of Chester requested an additional examination of the outcrops in the region along the anticline with a view to locating a second well whose position might be somewhat more favorable than that of the former well. Prominent among those specially interested in further developing the anticline are Mr. C. E. Kingsbury and Mr. William Ebers, both of Chester, Illinois. The writer wishes to acknowledge his indebtedness to these two gentlemen for kindly cooperation and for personal assistance while making a short field examination upon which this report is based.

The Bremen Anticline

In the tributaries on the eastern side of Little Mary's River the upper beds belonging to the Chester group of formations are well exposed. The Palestine sandstone and the Clore limestone in the NW. ¼ sec. 27, Bremen Township, show a distinct dip of 2 degrees to the southeast. The strike of these beds is about N. 70° E. The beds are well exposed along an east-west stream near the line between the farms of H. Magers and H. P. Wilson. One-half mile north of the outcrops mentioned immediately above is another east-west tributary in which the rocks are well exposed. Here, however, the dip is to the northwest and is much steeper than that of the beds mentioned at the first location. Near the center of the SW. ¼ sec. 22 a north

dip of 13 degrees was measured, but this is the strongest dip noted on the north side of the fold. Outcrops are plentiful on the Henry Heitman farm varies from 2 degrees to about 6 degrees. The south side of the anticline is much less clearly marked than the north. Slight southeast dips were noted in the SE. ¼ NE. ¼ sec. 27 on the Henry Schnoeker farm and also in the NE. ¼ NW. ¼ sec. 26. The dips here vary from 1 to 2 degrees.

It was found impossible to trace the anticline east from the Kiskaddon well near the center of sec. 23, since the rocks do not outcrop in the critical territory. In the SW. ¼ sec. 19, T. 6 S., R. 5 W., and in the NW. corner sec. 30, of the same township, the lowermost rocks of the coal measures come to the surface, but here all the beds lie flat.

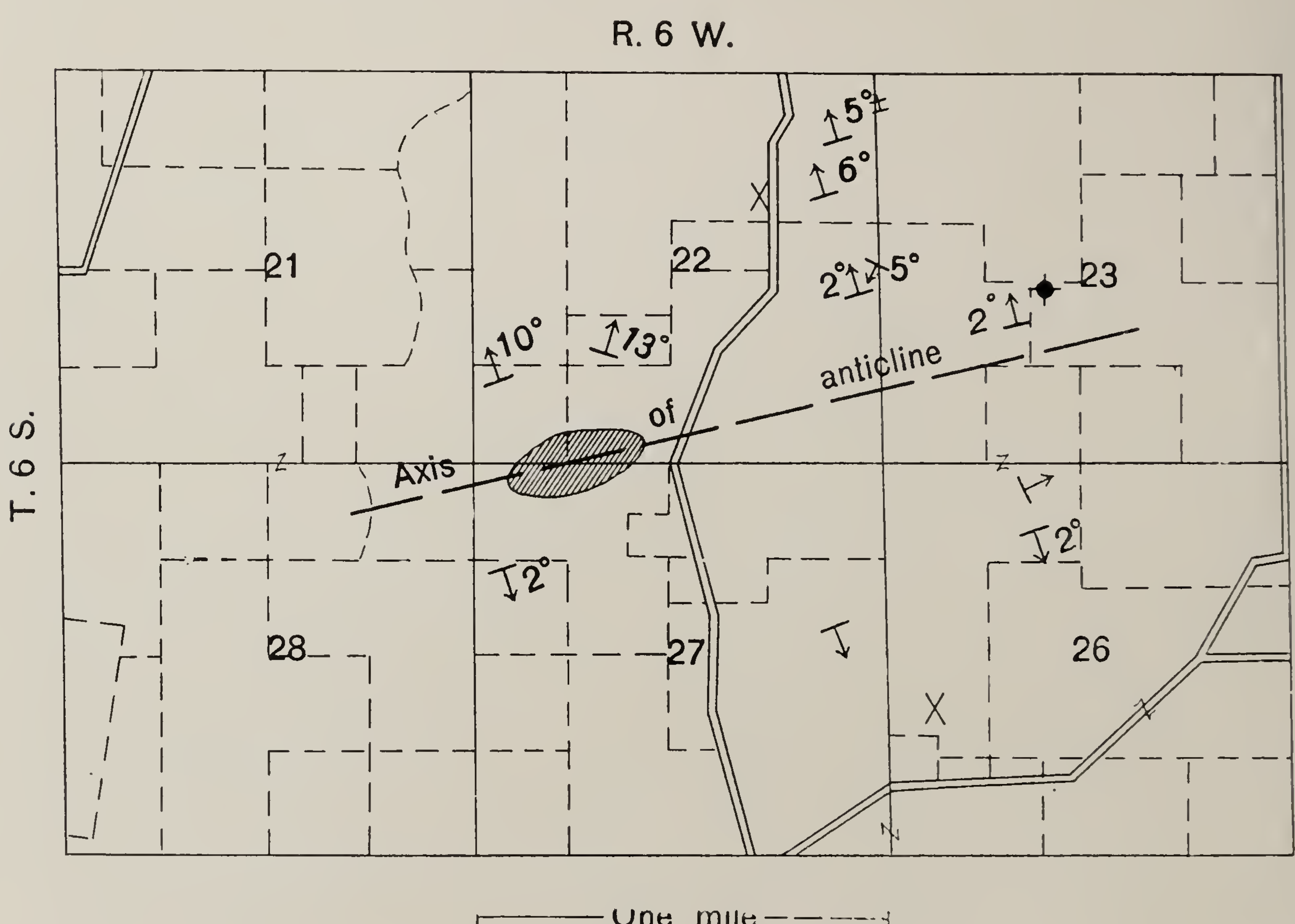


FIG. 9.—Map of Bremen anticline.

Arrows show direction and amount of dip. Kiskaddon well indicated by black circle. Suggested location for second well shown by shaded area. Crosses indicate outcrops at which dip is not measurable.

in the NE. corner of the SE. ¼ sec. 22, and on the Frederick Hogrefe farm in the NE. ¼ sec. 22. The dip at these outcrops is to the north and

SECOND WELL RECOMMENDED

The Survey believes that the Bremen anticline deserves one more test which should be located as near as possible on the axis of the fold. It is suggested that the second well be placed near the southwest end of the fold where the dips are most pronounced and where the axis of the anticline may

be closely located. A well in the shaded area as shown in figure 9 would test the anticline in as favorable a location as can be selected. It is thought that the well need not be more than 700 feet deep to test the entire thickness of the Chester beds and to penetrate enough of the Ste. Genevieve limestone to determine its possibilities.

Lack of Other Folds

An examination was made to determine the presence of any other anticlines in the vicinity, but the outcrops failed to disclose any favorable structure except the Bremen anticline. Field work was confined to the SE. ¼ of T. 6 S., R. 6 W., and to secs. 19 and 30 of T. 6 S., R. 5 W.

OIL AND GAS IN THE BIRDS QUADRANGLE

By John L. Rich

(In cooperation with the U. S. Geological Survey)

OUTLINE

ILLUSTRATIONS

INTRODUCTION

Purpose and Scope of Report

This report deals with the occurrence of oil and gas within the Birds quadrangle, which includes the eastern part of the main Illinois oil field in southern Crawford and northern Lawrence counties. The field work was done during the summer of 1915 in cooperation with the United States Geological Survey, and the results will appear in briefer form in the Hardinville-Birds folio now in preparation by the United States Geological Survey. But since the folio text must necessarily be brief and there is likely to be considerable delay in its publication, the State Geological Survey has deemed it advisable to prepare for immediate issue this bulletin in which a full account of the results of the investigation is presented. The report deals only with the area included in the birds quadrangle which lies between longitude 87°30′ and 87°45′ and latitude 38°45′ and 39°.

For an oil field like that of the Birds quadrangle where the productive territory has been fairly well outlined, it is the principal function of an oil report to present a description of the conditions under which the oil occurs; a discussion of the structures responsible for the oil accumulation; and any facts which throw light on the problem of the origin of the oil or on the laws which have governed its accumulation, or that may be of value in guiding future explorations in this or other regions where the geological conditions are similar. The report is intended primarily as a contribution to the

geological theory of the origin and mode of occurrence of oil in the Pennsylvanian rocks of Illinois.

In the field each well, whether producing or dry, was located, and the elevation at its mouth ascertained. For the greater part of the area, including that part in which the wells are closely spaced, the locations and elevations were determined by means of a plane table and telescopic alidade, and the work was done with great accuracy. Scattered wells and dry holes were located by pacing from road corners and other points which could be identified on the contour map, and their elevations were determined by hand level. The wells in sec. 15, T. 5 N., R. 12 W., (Honey Creek Township), and many of those in sections 9, 10, and 16 of the same township were located, and their elevations determined in previous years by Mr. R. S. Blatchley of the State Geological Survey.

Acknowledgments

Special acknowledgement is due to Mr. W. S. Nelson of the State Geological Survey, to whom was intrusted the plane table work and the drafting of the accompanying maps, and to Messrs. E. F. Rehnquist and John Hazlett Bell for able cooperation as rodmen. Grateful acknowledgment is here made to one and all of the numerous oil companies and individual operators who furnished logs of the wells, without which no detailed study of the field could have been made. To Professor T. E. Savage and Mr. F. H. Kay of the State Geological Survey, with whom the writer has counseled freely in connection with the preparation of the report, acknowledgment is also due.

PHYSIOGRAPHY

The broad flood plains and terraces of Wabash and Embarrass rivers occupy respectively the eastern and southern portions of the quadrangle. The remainder of the area, except for about 20 square miles of low, gently rolling topography in the northwestern part of the quadrangle, south and east of Robinson, and a strip of lowland along Brushy Creek from one to two miles wide extending south past the villages of Flat Rock, Birds, and Pinkstaff to the Embarrass flats, is a maturely stream-dissected upland divided by the lowland of Brushy Creek into an eastern and a western section. The upland has a relief of 100 to 150 feet.

The Wabash and Embarrass flood plains and terraces range in elevation between 415 and 445 feet above sea level. They determine the base level to which all the secondary streams have graded their flood plains. The terraces are sandy and gravelly and lie in general above the level of high water. The low flood plains, however, are covered by water at times of flood and are frequently more or less swampy for long periods. Roads on low flood plains, unless properly graded, are almost impassable for

long periods after high water. Terrace roads as a rule are good at all seasons. The low, alluvium-filled valley of Brushy Creek is poorly drained (except near the drainage ditch), and its roads are frequently bad after wet weather.

The uplands in general are very rough, the western more so than the eastern, since it is higher and more sharply cut by the streams. The highest point in the quadrangle, 645 feet, is in this western upland. The upland roads are prevailingly rough, though in wet weather they are more passable than those on the undrained flats. The prevailing system of laying out the roads on the section lines in defiance of local topography is to a considerable extent responsible for their roughness, since many of the hills might have been avoided had the roads been located in harmony with the topography. On the steep hills the roads wash badly.

GEOLOGY

Unconsolidated Rocks

Glacial drift, alluvium, loess, and wind-blown sand, named in order from the older to the younger, constitute the unconsolidated mantle rocks of the region. The drift is pebbly bowlder clay (till) with some gravel and sand. Where fresh it is blue, but it is commonly oxidized to a yellow color for ten feet or more below the surface. It varies in thickness from a few inches to about 100 feet. In general it is thickest in the valleys and thinner on the hill tops.

The alluvium overlies the drift in all the stream valleys, but its greatest development is along Wabash and Embarrass rivers, where it constitutes the extended flood plain and terraces above described. Along Wabash and Embarrass rivers the terraces are mainly gravel, but the low flood plains, at least at the top, consist mainly of clay loam, sand, or fine gravel. The maximum depth of alluvium in the Wabash valley is not known, but a well in the SW. cor. sec. 20, T. 4 N., R. 10 W., passed through 102 feet of gravel and quicksand before reaching bed rock. Two borings on the low flood plain of the Embarrass, one in the SE. ¼ SW. ¼ sec. 22, T. 4 N., R. 12 W., and another in the NE. ¼ sec. 25, struck rock at 50 feet. Numerous borings to the west and south of the quadrangle reveal from 75 to 90 feet of alluvium.

The loess, a fine wind-blown dust, forms a mantle from two to ten or more feet in thickness everywhere over the uplands except where the slopes are so steep that it has been eroded away. Along the bluffs of Wabash and Embarrass rivers the loess is locally much thicker.

Wind-blown sand occurs abundantly on the river terraces and on the bluffs bordering them. It commonly forms low, irregular, dune-shaped mounds, but along the river bluffs sand hills of considerable size are found.

Consolidated Rocks

GENERAL SECTION

The rocks beneath the drift down to the greatest depth penetrated by the wells belong to the Mississippian and the Pennsylvanian series of the Paleozoic system. A generalized geologic column for this part of the State is presented in tabular form below:

Pennsylvanian	McLeansboro	Shales and sandstones containing thin limestones and coal beds. Includes all the Pennsylvanian rocks above the top of No. 6 (Herrin) coal. Thickness, 500-700 ft. in Birds quadrangle; entire thickness not represented.
	Carbondale	Shales, sandstones, thin limestones and important coal beds. This formation includes all the rocks from the top of No. 6 (Herrin) coal to the bottom of No. 2 (Murphysboro) coal. Thickness, 300-350 feet.
	Pottsville	Sandstones and gray and black shales; thick sandstone beds dominate; few thin beds of coal. Thickness, 500-600 feet.
Mississippian	Chester	Limestones, shales, and sandstones; some red shales. Thickness, approximately 300 feet.
	Ste. Genevieve	Limestone, in part oolitic. Thickness about 85 feet.
	St. Louis and Salem	Mainly dense blue or gray limestones; thin sand beds. Thickness, 300 feet and over.

MISSISSIPPIAN SERIES

The data on the rocks of the Mississippian series are very meager. On the map, figure 13, are shown all the wells which are known to have penetrated these rocks.

ST. LOUIS AND STE. GENEVIEVE FORMATIONS

These formations can not be separated from each other in well records. The Ste. Genevieve is a soft, partly oolitic limestone about 85 feet thick. It grades downward into the St. Louis limestone, which is light blue and hard. The thickness of the St. Louis limestone in this area is not known because no wells within the quadrangle are known to have passed entirely through it. The character of the formation is well represented in the following logs of the Wash Parker and Lagow wells.

Log† of W. A. Lagow well, NE. ¼ NE. ¼ sec. 31, T. 5 N., R. 10 W.
(Elevation 436 feet)

Description of strata	Thickness *Feet*	Depth *Feet*
Soil and gravel	20	20
"Slate"	80	100
Sand	20	120
Lime	20	140
Sand	40	180
"Slate"	5	185
Lime	7	192
"Slate"	13	205
Lime	5	210
"Slate"	104	314
Sand (water)	36	350
"Slate"	3	353
Lime	2	355
"Slate"	170	525
Lime (water)	25	550
Sand (water)	65	615
Lime	3	618
"Slate"	42	660
Sand	50	710
"Slate"	19	729
Lime	2	731
Sand	11	742
"Slate"	10	752
Lime	10	762
"Slate"	18	780
Lime	10	790
"Slate"	35	825
Sand	8	833
Lime	2	835
"Slate"	85	920
Lime (water)	30	950
Sand (water)	60	1010
Lime	18	1028
Black slate	7	1035
Lime	22	1057
"Slate"	22	1079
Lime	11	1090
"Slate"	20	1110
Lime	70	1180
Sand	30	1210
Lime	12	1222
"Slate"	47	1269
Lime	3	1272
"Slate"	43	1315
Yellow lime	53	1368
Lime, white	32	1400
Sand (water)	70	1470

Description of strata	Thickness Feet	Depth Feet
Lime	15	1485
Red rock	3	1488
"Slate," white	5	1493
Lime	77	1570
"Slate," black	18	1588
Lime, hard	3	1591
Lime, soft	7	1598
Sand, oil, and water	3	1601
Lime	10	1611
Lime, soft, sandy	10	1621
Limestone	155	1776

†The base of the Pottsville formation cannot be recognized with certainty from this log. The top of the Ste. Genevieve formation ("Big Lime") is believed to be at 1,493 feet.

Log of Wash Parker well No. 7, SW. ¼ sec. 3, T. 5 N., R. 12 W., Honey Creek Township*

(Elevation 555 feet)

Water at	...	73
"Slate"	67	140
Water at	...	280
"Slate"	170	450
Coal	6	456
"Slate"	24	480
Hard shell	...	480
Show gas	10	500
Shells and lime	50	550
"Slate"	50	600
Hard shell	...	600
Coal	...	612
"Slate"	58	670
Shell	5	675
"Slate"	107	782
Water sand	16	798
"Slate"	34	832
Gas, good show	13	845
"Slate"	52	897
Shell	5	902
"Slate"	44	946
Stray oil sand	7	953
Water sand	90	1043
"Slate"	7	1050
Parker oil sand	5	1055
Shell	...	1075
Water sand	61	1136
"Slate"	4	1140
Water sand	88	1228
Shell	8	1236
Water sand	94	1330
"Slate"	20	1350
Water sand	50	1400

Description of strata	Thickness *Feet*	Depth *Feet*
Hole full of water	60	1460
Hard shell and lime	8	1468
Lime and dry sand	75	1543
Gas sand	17	1560
Oil, show of	5	1565
Hard lime and dry	15	1580
Water at	...	1582
Water enough to drill with at	...	1595
Lime, hard and dry	40	2035
Too much water to carry at	...	2035
Hole full and running over at	...	2055
Sand and slate to	...	2100
Limestone	95	2195
Limestone	25	2220
Water at	...	2220
Water sand	30	2250
Water increased	...	2250
Limestone	29	2279

*The Robinson sand is that between 946 and 1,043 feet; the base of the Pottsville formation (top of Chester group) is probably at 1,460, and the top of the Ste. Genevieve ("Big Lime") at approximately 1,595 feet.

Log‡ of H. B. Robinson well, SE. ¼ NE. ¼ sec. 25, T. 4 N., R. 12 W.

(Elevation 415 feet)

Surface	15	15
Quicksand	35	50
"Slate"	7	57
Quicksand	13	70
Red rock	5	75
Quicksand	38	113
"Slate"	17	130
"Slate"	30	160
Sand	70	230
Coal	5	235
"Slate"	5	240
Limestone	5	245
"Slate"	30	275
Sand	15	290
"Slate"	10	300
"Slate" and shells	30	330
Lime	15	345
"Slate"	5	350
Red rock	3	353
"Slate"	12	365
Lime	10	375
"Slate"	80	455
Coal	3	458
"Slate" and shells	27	485
"Slate", black	25	510
Lime	20	530

Description of strata	Thickness *Feet*	Depth *Feet*
"Slate"	125	655
Lime	5	660
Sand	40	700
"Slate" and shells	55	755
Coal	5	760
"Slate" and shells	55	815
Sand	30	845
"Slate"	35	880
"Slate" and shells	45	925
Sand	30	955
"Slate" and shells	65	1020
"Slate", black	10	1030
Lime and shells	10	1040
Bridgeport sand	15	1055
Water sand	15	1070
Lime	5	1075
"Slate"	5	1080
Sand	20	1100
"Slate"	10	1110
Sand	15	1125
"Slate" and shells	35	1160
Sand	10	1170
Lime	5	1175
"Slate"	73	1248
Lime	4	1252
"Slate"	5	1257
Lime	8	1265
"Slate"	5	1270
Hard lime	7	1277
Sand	13	1290
"Slate"	25	1315
Lime	5	1320
"Slate"	15	1335
"Slate" and shells	70	1405
Lime	44	1449
Water sand	3	1452
Hard lime	8	1460
"Slate"	45	1505
Lime	20	1525
Sand shells	10	1535
"Slate"	20	1555
Sand	23	1578
Lime	7	1585
Lime	5	1590
Sand	10	1600
"Slate"	35	1635
Water sand	25	1660
Lime	4	1664
"Slate"	16	1680
Water sand	10	1690

Description of strata	Thickness Feet	Depth Feet
Lime	5	1695
"Slate"	17	1712
Lime	13	1725
"Slate"	10	1735
Lime	5	1740
Lime, shells, and "slate"	36	1776
Hard lime	4	1780
Gritty lime	14	1794
Red rock	6	1800
"Slate" and shells	28	1828
Lime	7	1835
Red rock	5	1840
"Slate" and shells	50	1890
Sand, water	2	1892

‡In this log the base of the Pottsville formation cannot be identified with certainty. The two beds of red shale at 1,794 and 1,835 feet are interpreted to be those normally lying above the Kirkwood sand, which is, therefore, thought to be the sand at the bottom of the well. The "big lime" was not reached. The thickness of Chester rocks revealed by this well appears to be several hundred feet greater than in the Parker or Lagow wells.

In the Lagow well, NE. ¼ NE. ¼ sec. 31, T. 5 N., R. 10 W., green oil, probably equivalent to the McClosky oil of the main field of Lawrence County, was struck at a depth of 1,598 feet, or 1,162 feet below sea level and 338 feet above a datum plane 1,500 feet below the sea.[1] The yield was small, and the well was abandoned.

Oil at approximately the same horizon was struck in the W. O. Pinkstaff well, in the NW. ¼ sec. 8, T. 4 N., R. 11 W. (Bond Township), 1,700 feet below the surface or 238 feet above datum. The amount was too small to be of value. In a deep well on the S. J. Parker farm (Parker well No. 2), sec. 28, T. 6 N., R. 12 W., a few hundred yards west of the limits of the quadrangle, a showing of "green" oil was found in the hard and soft limestone at a depth of 2,029 feet, or 23 feet *below* datum. This is doubtless from a lower horizon than is the oil in the other wells.

The log of a deep well on the W. T. Highsmith farm, NW. ¼ sec. 14, T. 6 N., R. 12 W., from which samples were studied by Udden[2], shows limestone corresponding in character to the Ste. Genevieve limestone from a depth of 1,575 feet to 1,655 feet, and to the St. Louis limestone from 1,655 feet to the bottom of the hole at 1,940 feet. A showing of oil was reported at 1,580 feet.

CHESTER GROUP

The rocks of the Chester group consist of alternating beds of limestone, shale, and sandstone of moderate thickness. One or more beds

1On following pages all elevations unless otherwise stated will refer to height above an assumed datum plane 1,500 feet below sea level. Confusion owing to the variable elevation of the ground at the mouths of the wells is thereby avoided, and direct comparisons of the relative elevations of the strata described can be made.

2Udden, J. A., Some deep borings in Illinois: Ill. State Geol. Survey Bull. 24, pp. 113-114, 1914.

of red shale ("red rock") are found in the lower part of the formation. The Chester series may be distinguished from those of the overlying Pennsylvanian series by its characteristic composition of nearly 50 per cent of limestone and roughly 25 per cent of sandstone; whereas the rocks of the basal part of the Pennsylvanian are mainly sandstone.

Wells in the southwest corner of the quadrangle penetrate 250 to 400 feet of Chester rocks [3], as is shown by the log of the Robinson well, sec. 25, T. 4 N., R. 12 W. Elsewhere in the quadrangle, where, as will be shown, all the formation lie 300 to 400 feet higher than in the southwest corner, only the basal part of the Chester seems to be represented. The upper part seems to have been eroded away before the Pennsylvanian rocks were deposited.

The Chester rocks in the Birds quadrangle have not been found productive of either oil or gas, though traces of both have been reported from several of the deep wells. It is probable that over all the quadrangle except the southwestern corner the Kirkwood sand, elsewhere the most prolific oil-bearing horizon of the Chester, has been eroded.

PENNSYLVANIAN SERIES

The Pennsylvanian series in this region is represented by three formations. Named in order from the bottom up they are the Pottsville, the Carbondale, and the McLeansboro formations, the latter constituting the surface rocks.

POTTSVILLE FORMATION

The Pottsville formation lies at the base of the Pennsylvanian series. As revealed by the wells, it is 550 to 575 feet thick. Its base, which is reached in only a few wells, lies about 1,500 feet below the surface, or more exactly 573 feet above datum in the S. J. Parker well No. 2, in the SW. ¼ sec. 28, T. 6 N., R. 12 W.; 595 feet in the Wash Parker well No. 7, SW. cor. NE. ¼ sec. 3, T. 5 N., R. 12 W.; and 698 feet (or possibly 608 feet depending on the uncertain correlation) in the W. O. Pinkstaff well in the center of the NW. ¼ sec. 8, T. 4 N., R. 11 W. (Bond Township). The formation is prevailingly sandy but contains numerous beds of shale and some thin limestones and lenses and stringers of coal.

The Robinson sand, the most important oil-producing sand in the quadrangle, lies in the Pottsville formation 450 to 475 feet above its base and, it is thought, 50 to 100 feet below its top. The latter boundary of the formation, however, is not easily distinguished. The gas sands oc-

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[3]On account of the impossibility of distinguishing, in the well records available, the exact boundary between the Chester and the Pennsylvanian rocks, the exact thickness of the Chester is not known.

curring within the first 100 feet above the Robinson sand are thought to be near the top of the Pottsville.

Below the Robinson sand, the sandstones of the Pottsville are as a rule filled with salt water.

CARBONDALE FORMATION

The Carbondale formation is 300 to 350 feet thick. Roughly, it extends from sea level to 300 feet below the sea, or from 1,500 to 1,200 feet above a datum plane 1,500 feet below sea level. In composition the Carbondale formation does not differ essentially from the next higher formation except that it is richer in coal beds. The shallow gas sand described on following pages lies near the middle of this formation.

Coal No. 6, which marks the top of the Carbondale, was found in well No. 9 on the C. T. Cochran farm[4] in the NE. cor. SW. ¼ sec. 21, T. 5 N., R. 11 W. (Montgomery Township), to lie 40 feet below sea level or 563 feet below the surface. In other wells in this and adjoining quadrangles, this coal lies very near sea level; in some slightly above, in others below. The general accordance of the levels at which the coal was found indicates that the Pennsylvanian rocks of the region have never been greatly deformed.

MCLEANSBORO FORMATION

The rocks which outcrop at the surface are light and dark-gray shales and yellow and white sandstones containing an occasional thin bed of limestone or coal. They belong to the McLeansboro formation approximately 500 feet above its base. The surface rocks are very flat over the entire quadrangle.

Below the surface, the McLeansboro formation, as revealed in the logs of the wells, is composed mainly of gray, micaceous, sandy shale. There are also thin beds of black, carbonaceous shale, limestone, and sandstone. In the lower 250 feet of the formation one or more thin coal beds are found.

GAS

Horizons for Oil and Gas

Oil and gas is, or has been, produced in commercial quantities from several sand horizons at levels ranging from 1,565 feet down to 1,023 feet above a datum plane 1,500 feet below sea level. This represents 435 feet to 1,100 feet below the surface of the ground. The principal productive horizons fall into three groups: (1) shallow gas sands at 1,400 feet, more or less, above datum, or about 650 feet below the surface; (2) intermediate gas sands at 1,100 to 1,300 feet; and (3) the Robinson oil and

[4]Udden, J. A., Some deep borings in Illinois: Ill. State Geol. Survey Bull. 24, p. 117, 1914.

gas sand, which lies at elevations ranging between 1,030 and 1,100 feet above datum. Of these by far the most important, and practically the only one from which oil is produced, is the Robinson sand. This sand receives its name from the fact that it is the productive sand in the pool northwest of the city of Robinson, the first important oil pool to be developed in this vicinity.[5] Almost all the shallow wells in Crawford County obtain their oil from this horizon.

The Robinson sand lies near the top of the Pottsville formation of the Pennsylvanian series. It is encountered in the wells at depths varying from 850 to over 1,100 feet, depending on the elevation of the surface of the ground and on the level of the sand with respect to the sea.

Shallow Gas Sands

The highest productive horizon is found in the SE. ¼ sec. 2 and the SW. ¼ sec. 1, T. 5 N., R. 12 W. (Honey Creek Township), where in at least two wells gas is produced from a sand at 1,550 feet above datum. In five other wells sand, some of which contained gas, was reported at this level, but the principal supply of gas came from deeper sands (Pl. IV). This gas horizon is very close to coal No. 6.

The most widespread productive bed of the higher sands is a gas sand found over a large part of the northern and western portions of the quadrangles at about 1,400 feet above datum. From its average depth below the surface this sand is known locally as the 650-foot gas sand. The largest and most important area from which it has yielded gas includes the greater part of secs. 35 and 36, T. 6 N., R. 12 W. (Honey Creek Township), and adjacent portions of the surrounding sections. Owing to the short life of the wells this gas field has been considered to be nearly exhausted. It is only since November, 1914, that the discovery of oil in the Chapman pool, sec. 3, T. 5 N., R. 12 W. (Honey Creek Township), has attracted attention to this portion of the field and has led to deeper drilling. All but a few of the original gas wells in this vicinity are now abandoned.

During the period from 1910 to 1912 a small gas field was developed near the village of Duncanville in sec. 24, T. 6 N., R. 12 W. (Honey Creek Township). This proved short-lived and most of the wells were abandoned within a year. None are now in operation. The gas was obtained from the shallow sand at about 1,400 feet above datum. Since the wells penetrated only a few feet into the sand, its thickness is unknown.

Near the center of sec. 18, T. 6 N., R. 12 W. (Lamotte Township), three or four gas wells, two of which are now abandoned, obtained their

[5]Blatchley, R. S., Oil and gas in Crawford and Lawrence counties: Ill. State Geol. Survey Bull. 22, p. 14, 1913.

supply from this sand which here is only about 30 feet in thickness. No water was reported in the sand.

Another small gas-producing area in which the gas comes from sand at 1,400 feet elevation is found along the line between secs. 14 and 23, T. 5 N., R. 12 W. (Honey Creek Township). Five wells have drawn gas from this sand.

Over much of the remainder of the Birds quadrangle sand is reported at levels between 1,350 and 1,430 feet above datum. In general the sand contains water, but locally it holds gas at the top. Over the New Hebron oil pool this sand is reported in many of the wells as a thick water sand at the top of which in some places gas is found. Over the Birds oil pool in T. 5 N., R. 11 W., a thick water sand at this horizon is reported. It is, however, barren. This shallow sand varies greatly in thickness and, although widely developed, is probably not continuous over the entire field. The drill is the only means of testing its gas possibilities.

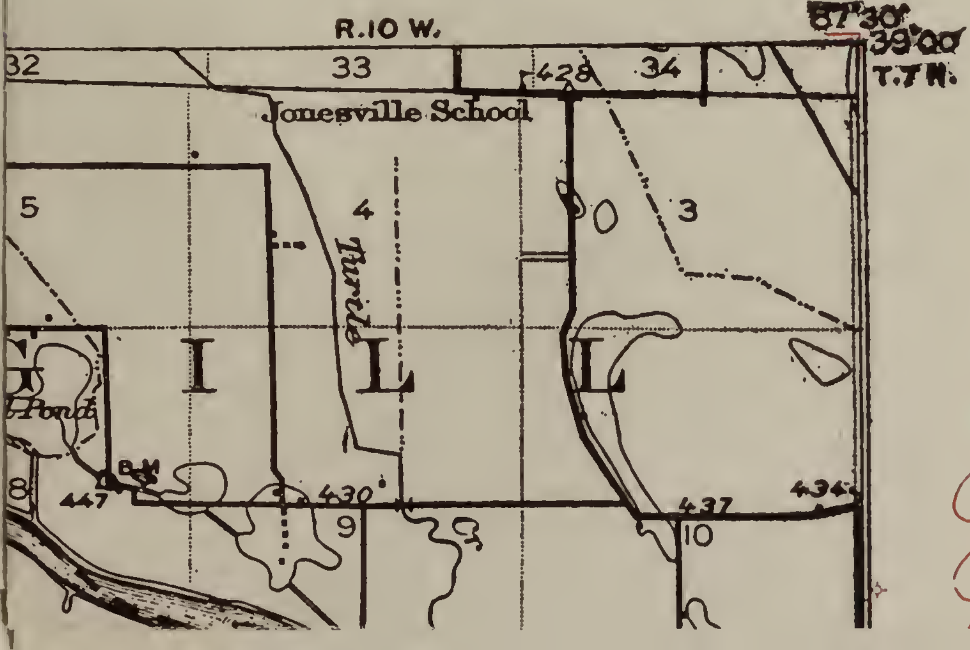
Robinson Gas Sand

In at least six localities in the quadrangle gas has been drawn in considerable quantity from sands which correspond neither to the shallow 1,400-foot gas sand nor to the Robinson oil and gas sand, which lies from 1,030 to 1,100 feet above datum. These intermediate gas sands are marked by great irregularity in their occurrence both vertically and horizontally. They are found at intervals in a zone ranging in elevation from 1,110 feet to 1,250 feet above datum, though in a single area the production commonly comes from a single lens or closely related lenses at approximately equal altitudes. This horizon lies either at the top of the Pottsville formation or at the base of the Carbondale, probably the former. The principal areas in which this gas of moderate depth has been found are indicated on the map (Pl. IV). A short description of each follows.

Canaan Gas Pool

In the vicinity of Canaan church and school, near the common corner of secs. 13 and 24, T. 5 N., R. 11 W., and secs. 18 and 19, T. 5 N., R. 10 W. (Montgomery Township), a small isolated gas pool was discovered and developed during the summer of 1913. By August, 1915, ten wells had been drilled two of which had proved to be dry, three had been abandoned, and another was being used only to supply a farm house. The gas was found in a sand at 1,110 to 1,133 feet above datum. The gas sand appears to be of very limited extent, but the possibilities of slight extensions of the field seem not to have been exhausted. The Robinson sand underlies this gas pool at 1,040 to 1,050 feet, but is filled with salt water.

BULLETIN NO. 33, PLATE IV



Producing oil well

Abandoned oil well

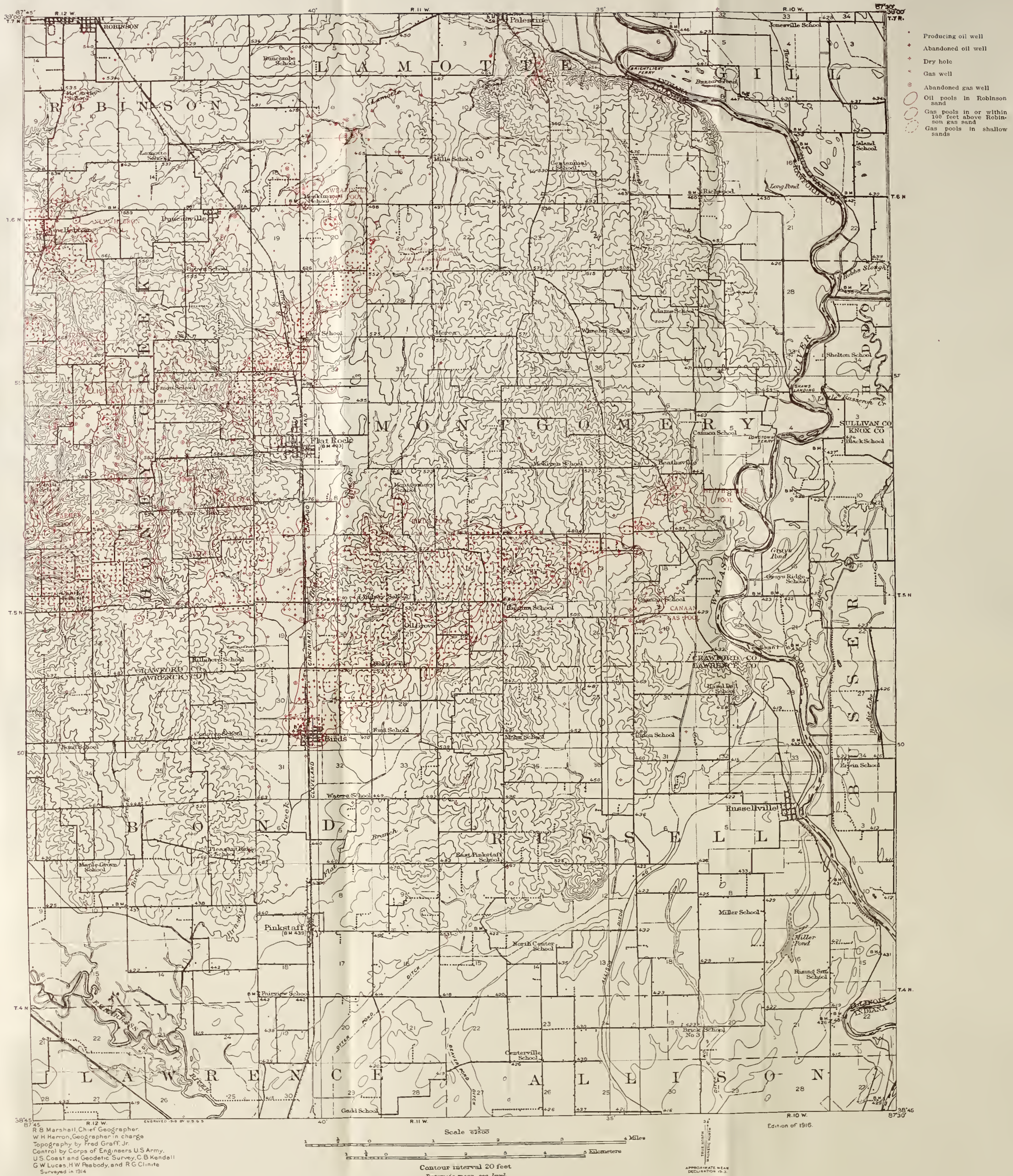
Dry hole

Gas well

Abandoned gas well

Oil pools in Robinson sand

Gas pools in or within 100 feet above Robinson gas sand



Map showing oil field in Birds quadrangle

Heathsville Pool

In sec. 7, T. 5 N., R. 10 W. (Montgomery Township), gas is found in from one to three sands between 1,100 and 1,203 feet above datum. The sands are lenticular and very irregular. The field forms the eastern extremity of the Birds oil pool, and the majority of the wells pass through the gas sand into the Robinson oil sand below. Such wells produce both gas and oil.

Minor Gas Pools

Around the common corner of secs. 8, 9, 16, and 17, T. 5 N., R. 11 W. (Montgomery Township), over the outlier of the Birds oil pool in the Robinson sand to be described on the following pages, a gas sand is found at elevations of 1,123 to 1,170 feet above datum.

Other small areas in which gas sand at this horizon is found are in the SE. cor. sec. 14 and the NW. cor. sec. 24, T. 5 N., R. 12 W. (Honey Creek Township), and in the SE. ¼ sec. 30, T. 5 N., R. 11 W. (Bond Township).

In the eastern half of sec. 3 and the western part of sec. 2, T. 5 N., R. 12 W.; and the SE. ¼ sec. 34, T. 6 N., R. 12 W. (Honey Creek Township), gas is found at several levels within the general horizons under discussion. There seem to be several gas lenses at the levels ranging from 1,110 to 1,300 feet. This region constituted the Shaffer-Smathers gas area in which in November, 1914, by deeper drilling oil was discovered in the Robinson sand, and the so-called Chapman pool was opened. The gas undoubtedly was derived in part from the upper lenses of the Robinson sand. Previous to the opening of the Chapman pool, hope of finding oil in the lower sand seems to have been given up following the drilling of scattered deep wells in which no paying quantities of oil were found. Several scattered gas wells, all but one of which are now abandoned, have been drilled in secs. 7, 8, 9, and 17, T. 6 N., R. 11 W. (Lamotte Township). Their gas supply came in part from sands at various levels between 1,100 and 1,300, in part from the Robinson sand at 1,070 to 1,080 feet above datum. Great irregularity characterizes the sand of this vicinity.

Wells near Palestine, secs. 2, 3, and 11, T. 6 N. R. 11 W. (Lamotte Township), tapped gas at one to three levels at the horizon under discussion. At least three of these wells were drilled down to the top of the Robinson sand but obtained only a showing of oil.

OIL IN ROBINSON SAND

The territory in which the Robinson sand is productive falls naturally into several districts, units, or pools, each of which it will be shown is quite distinct and independent of the others (Pl. V). In the following sections each pool is described in detail and the facts which form the

basis of the discussion of the origin of the oil sand and the conditions which have controlled the oil accumulation are presented. The various pools are described approximately in the order of their development.

Description of Pools

PARKER POOL

GENERAL DESCRIPTION

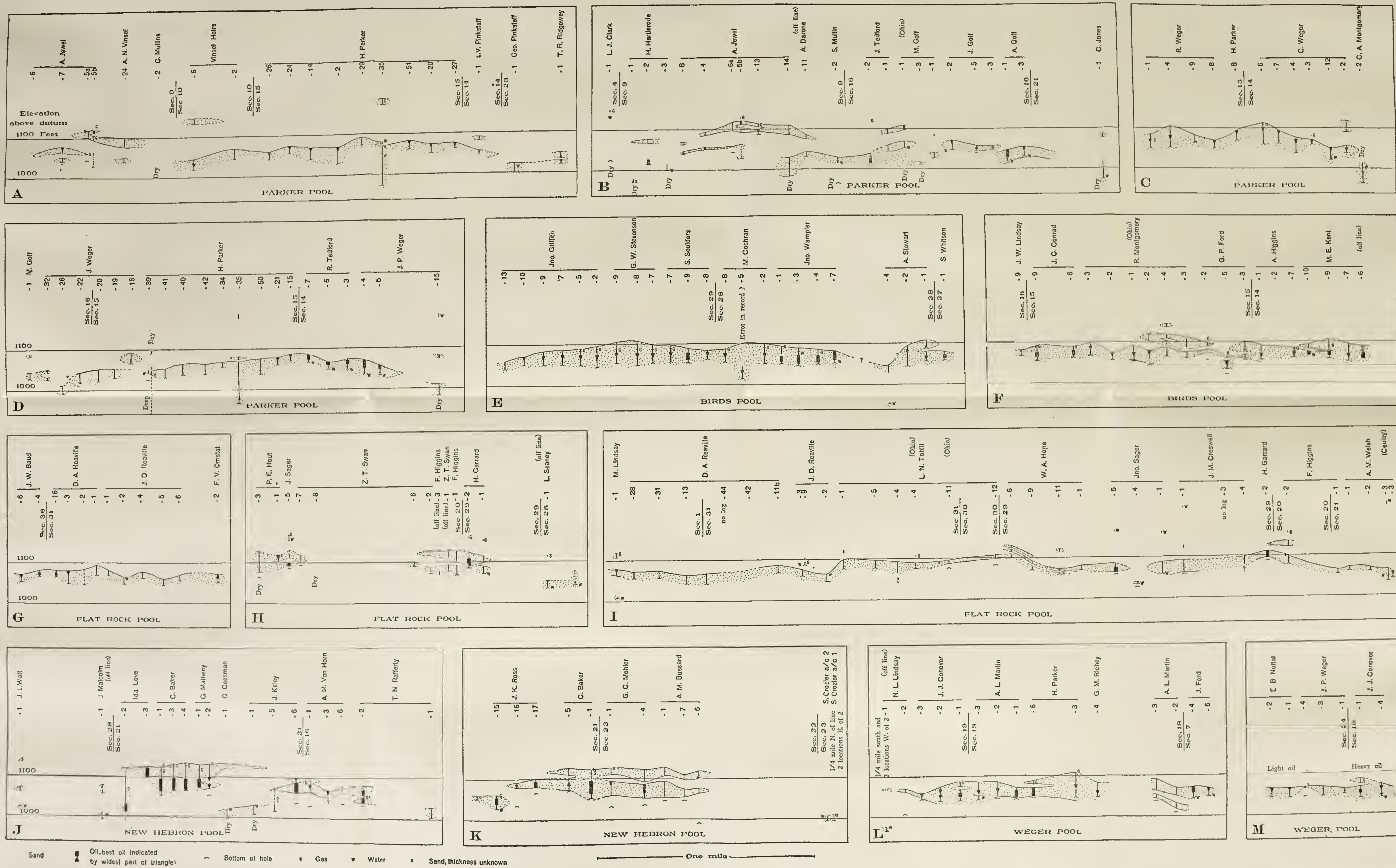
The Parker pool, in which oil was first discovered within the quadrangle, underlies an area of about 2¾ square miles in secs. 9, 10, 11, 14, 15, and 16, T. 5 N., R. 12 W. (Honey Creek Township). Like the Flat Rock and New Hebron pools, described on following pages, it is entirely isolated from other producing areas. The main body of the pool in section 15 and adjacent portions of sections 10, 11, 14 and 16 is the most compact and, for its area, one of the richest pools in the quadrangle. Section 15 contained 130 wells of which all but 12 were productive. The outlying portion of the pool in section 9 is practically distinct from the main body, not only in position but also in the character of its sands. The northeastern prolongation in section 11 is also somewhat isolated. The limit of the pool seems to have been very closely determined by test wells around most of its border except on the southwest, where there seems to be a possibility of slight extension. On the south and southeast the border is very sharp.

The field was developed and the productive territory closely outlined mainly during the years from 1907 to 1910.

DESCRIPTION OF OIL SAND

The production comes mainly from a thick, continuous bed of sand whose limits seem to be closely indicated by those of the producing area. The sand is penetrated to depths of 20 to 40 feet in the majority of the wells, but very few pass entirely through it. In the central part of the field (see Plate V, A, B, C, and D.) the top of the sand lies from 1,045 to 1,100 feet above datum. At the west end the sand breaks up into a number of smaller lenses of very irregular form and elevation (Plate V, A, B.). On the south and southeast borders it either pinches out, or its surface descends steeply toward the southeast, for from producing wells at 1,055 to 1,070 feet above datum there is a drop in the wells on the next location only 400 feet distant of 30 to 50 feet to a water sand lying almost flat at about 1,020 feet (Plate V, A, C, and D). From the abrupt character of this descent and from the nearly flat-lying attitude of the lower water sand, it seems more probable that the oil sand pinches out than that it dips down so steeply.

Near the common corner of sections 10, 11, 14, and 15 the top of the sand presents very great irregularities in the form of mounds and hollows which have a relief of over 50 feet and a width of from 1,200 to



Profile sections of Robinson sand in Birds quadrangle

2,000 feet (Pl. V, C). That the irregularity is due to irregular heaping up of the sand, not to structure, is indicated by the fact that the sand is very thick in the mounds.

A marked ridge in the surface of the sand extends in a direction a little east of north through the western part of section 15 (Pl. V, D). It is due to a thickening of the sand at the top which develops locally into a narrow lens separated from the main sand body by shale, but elsewhere is joined with it. Immediately east of this ridge, in the SE. ¼ NW. ¼ sec. 15, is a low depression in which the sands are very thin and bear only water. Except along the western side there is no marked splitting up of the Parker sand bed into lenses. The partially isolated outlier in section 9 consists of very irregular lenses of sand, the principal and the most productive of which lies at an elevation about 30 feet above the top of the sand in the main mass in section 15. The lenses are thin and not distinctly connected with the sand in the main pool. The wells produce considerable gas with the oil, and the oil is reported to be 2 or 3 degrees Beaumè lighter than in the main pool.

POSITION OF OIL IN SAND

Except in a very few wells the oil in the main body of the Parker pool lay at the top of the sand. Here and there it was reported to lie 10 to 20 feet below the top, but such cases were exceptional. Even in the local high spots in the surface of the sand the oil commonly extended to the top. The oil is reported to be heavy.

WATER CONDITIONS

In the main body of the pool water fills the lower part of the sand. The water records given in the well logs are so incomplete that a more detailed statement can not be made. A peculiar feature, however, manifested in the eastern part of the field (Pl. V, D) is a progressive lowering of the water level toward the east in a continuous bed of sand. This feature is so marked that the easternmost producing well draws its oil from a level slightly below that of the salt water in a well four locations, or 1,600 feet, to the west in the same bed of sand. This seems to indicate that the relative positions of water and oil may to some extent be controlled by capillarity rather than by the ordinary laws of hydrostatics.

In the local lenses on the western border of the field and in section 9 the distribution of the oil and water is irregular. Each lens seems to be independent of the others. In any single lens the water lies in the lower part and the oil in the upper part of the sand. Water in one lens may, however, lie above oil in an adjacent lower lens, an indication that the lenses are not closely connected. (See Plate V, B.)

STRUCTURE

On the whole, taking into consideration the irregular character of the western end of the pool and its outliers, together with the abrupt limit of production along the southeastern side, it appears probable that the Parker pool is due to an accumulation of sand at the Robinson horizon in beds elsewhere impervious, rather than to structural arching or doming of the strata. Such probability is strengthened by the fact that many of the dry wells outside the producing area are reported to have struck no sand or only very thin sand.

BIRDS POOL

GENERAL DESCRIPTION

The Birds pool is the largest of four principal producing fields within the Birds quadrangle. It extends in a direction about N. 30° E. from the western side of the village of Birds in the E. ½ sec. 30, T. 5 N., R. 11 W., Bond Township, for a distance of seven miles to the center of sec. 7, T. 5 N., R. 10 W. (Montgomery Township). Its greatest width is a little over two miles. A loosely connected outlier extends westward into secs. 17 and 18, T. 5 N., R. 11 W., and another is found round the common corner of secs. 8, 9, and 16. The most prolific part of the pool is in secs. 14, 15, 16, 20, 21, and 22, Montgomery Township, and in sec. 29 and the northern part of sec. 28, Bond Township, all of T. 5 N., R. 11 W. The extreme eastern end of the pool in section 7, Montgomery Township, is separated from the other producing territory by one-half mile of untested ground.

A noteworthy feature of the main pool is a narrow strip of productive territory which marks its almost perfectly straight southeastern margin in the NE. cor. sec. 28, Bond Township, and in secs. 22 and 23, and the southern part of sec. 14, Montgomery Township. This narrow productive area is separated from the main body of the pool by a strip of unproductive ground about one-quarter mile in width.

DESCRIPTION OF THE OIL SAND

In the main body of the pool the producing sand is struck at elevations ranging from 1,060 to 1,110 feet above datum—most commonly between 1,080 and 1,100 feet. In the southwestern part of the field secs. 20 and 21, Montgomery Township, and 28 and 29, Bond Township, there is a single thick bed of sand penetrated by the wells to depths of 20 to 60 feet. (See Pl. V, E.) In it the oil lies at an almost uniform level of 1,070 feet, in spite of the irregularity of the top surface of the sand which amounts to as much as 40 feet. Gas occurs in most of the wells in the sand about 10 feet above the oil. That water lies in the lower part of the sand is inferred from the fact that all the wells end at about 1,050 feet above datum, and that at this level water is reported in a few of them.

The conditions as regards sand, oil, and water in this part of the field are well shown on the profile. In the central part of the pool in sections 15, 16, and 21 the conditions are much the same as in the southwestern portions except that here and there the upper part of the sand rises above the shale parting and fingers out, and a few local lenses appear at higher levels, from 1,100 to 1,140 feet above datum. On the northwestern side of the pool the principal sand beds thin to less than 20 feet. Over most of section 16 the sands are very irregular. Here the oil lies at an almost perfectly uniform level of 1,070 feet, and there is gas about 15 feet above —whether in the top of the oil sand or in a higher gas sand could not be determined from the well records.

A pronounced local lens at an elevation slightly higher than the general level appears in the southern quarter of section 16. It is similar to the outfingering lenses in section 14 described below, and like them is probably connected at some point with the main sand mass.

The partly isolated producing strip which marks the southeastern border of the pool (Pl. V, E, right) appears to be a local reef along which the sand is piled up higher and thicker than in the barren territory between it and the main body of the pool.

In section 14 the regularity which characterizes the sand in the section to the west (sec. 15) largely disappears. In the southern half of the section the fingering lenses shown on the profile (Pl. V, F.) introduce a great deal of irregularity; in the northern part and in sections 11 and 12 the sand lies low, and water is found near its top in most of the wells. Above the water there appears to be only a scum of oil. At the eastern end of the pool in sec. 7, T. 5 N., R. 10 W. (Montgomery Township), the irregularity is still greater on account of the presence of several local lenses at elevations higher than that of the sand in the main body of the pool to the west. The lower of these lenses at about 1,090 feet above datum produces the oil, and higher lenses at 1,120 to 1,203 feet yield considerable gas.

It is doubtful if the oil-bearing sand in this portion of the field connects directly with that farther west.

The outliers of the Birds pool in sections 8 and 9 and the northern part of sections 16 and 17, Montgomery Township, are partly isolated from the main body, though their oil is produced from about the same horizon. This area is characterized by great irregularity in its sand. The oil sand is subject to marked variations in thickness and thins out toward the north and northeast from its thickest part in the NE. ¼ sec. 17 into diverging, outfingering beds separated by shale. A gas-bearing sand is found at elevations of 1,121 to 1,146 feet above datum in the wells in the southwestern part of this area. Gas is also found not uncommonly in the upper lenses of the oil sand in places where it fingers out to two

or more distinct beds. Considered as a whole this oil pool seems due to a lens of sand which is thickest near the northwest corner of section 17 and splits and thins out toward the north and northeast. The limits of this area have been closely determined by drilling.

Near the common corner of sections 17, 18, 19, and 20, T. 5 N., R. 11 W., is a moderately productive outlier of the Birds pool. The sands here are thin and relatively uniform (see stereogram, Pl. VI). Their thickness averages only 10 to 20 feet, though locally it is as great as 40 feet. The majority of the wells pass entirely through the sands into the underlying shales. The stereogram shows clearly that thickening and thinning of the sand beds is of dominant importance in determining the high and low places on its surface. The characteristic splitting off of beds into separated lenses is also distinctly revealed. Where such splitting has occurred and two sand beds are separated by shale, gas is commonly found in the upper, and oil in the lower bed. The sands particularly where thickened at the top, are not completely saturated with oil. Water lies in the bottom of some of the lower depressions in the sand beds. The conditions in this outlier are particularly significant when compared with those in the main field to the south. Here the sand beds are thin and low; there they are thick, and the thickening appears to be at the top, for the bottom of the sand in the 10- to 20-foot bed of the outlier is at about the same level as the bottom of the majority of the wells in the main field to the south, but these wells end in sand about 60 feet below its top. Thus a thickening of the sand at the top to the extent of 40 to 50 feet is indicated.

FLAT ROCK POOL

The Flat Rock pool is a long, narrow, and compact area of producing territory distinctly isolated from neighboring pools. It extends from the NE. ¼ sec. 1, T. 5 N., R. 12 W. (Honey Creek Township), in an almost straight line northeastward for four miles to the SW. ¼ sec. 21, T. 6 N., R. 11 W. (Montgomery Township). Its width ranges from one-half to three-quarters of a mile, being greatest at the south end. In its narrowest part in the west center of sec. 29, T. 6 N., R. 11 W., an area with a large proportion of dry holes, nearly divides the pool into two parts. The oil is produced from the Robinson sand at elevations ranging from 1,050 to 1,110 feet above datum, but the majority of the wells obtain oil from levels between 1,070 and 1,080 feet.

The extreme southern end of the pool in sections 1 and 6, Honey Creek Township, is characterized by great irregularity in the sand. Correlations can scarcely be made from one well to the next. In general one or more gas sands overlie the oil from 50 to 100 feet above it, but the oil lies at levels which differ as much as 30 feet. Near the north line of sections 1 and 6 the sand bed becomes continuous and from 30 to 70 feet

thick and is penetrated by very few wells. Its surface presents a series of ridges and hollows extending northeast and southwest parallel to the trend of the pool (Pl. V, G). These persist northward at least to the north line of section 31 and characterize all the widest part of the pool. Water stands near the top of the sand so that wells in the hollows have either struck water at the start or have been small and short-lived producers. Most of the producing wells yield abundant salt water with the oil. Furthermore, salt water in this region is proving very troublesome on account of the great rapidity with which it corrodes all casings and pipes.

In the narrow middle part of the pool the sands become broken into several thin beds, and many dry holes and abandoned wells testify to the spotty character of this portion of the field. On the Tohill and Hope farms, SE. ¼ sec. 30, T. 6 N., R. 11 W. (Honey Creek Township), and SW. ¼ sec. 29, Montgomery Township, the sands are heaped up to 30 or 40 feet above their normal height, and three thin lenses overlie the main body of the sand whose thickness is unknown, since the wells end in sand (see Pl. VI).

Near the north end of the pool in the SE. ¼ sec. 20 and the NE. ¼ sec. 29, Montgomery Township, is the small Higgins pool. In this pool the sands consist of two lenses, one above the other, both of which thicken in the middle till they join, and taper out at each end (Pl. V, H). Above both, at about 1,150 feet, is a thin gas sand. The extreme northeastern end of the pool, in the SW. ¼ sec. 21, Montgomery Township, lies on a flat terrace at 1,060 to 1,070 feet, about 30 feet below the top of the sand in the SE. ¼ sec. 20 (Pl. V, I, right). On this terrace the wells have been poor and most of them short-lived. This is due to the fact that the oil is closely underlain by water which breaks through at the shot or later and ruins the well. The initial production of these wells is low but sufficient to have stimulated repeated drillings. (During the winter and spring of 1916 this field has been extended eastward into the SE. ¼ sec. 21, and a few good gas wells have been drilled in the north half of section 22.)

The Flat Rock pool as a whole is an area in which the top of the sand lies from 30 to 50 feet above the level of the sands in adjoining areas at either side; but the character of the surface with its parallel ridges and its fingering lenses is such as to indicate that the elevated position of the top of the sand is due to its mode of deposition rather than to deformation of the stratum after it was deposited. A profile along the axis of the pool (Pl. V, I) shows that the level of the top of the axis is variable and that there is no noticeable plunge in either direction.

Over the southern and widest part of the Flat Rock pool the shallow gas sand, roughly 1,400 feet above datum, was reported in several of the wells and has been drilled in some places for its gas which is used for

pumping. This gas sand is reported as being thick and to contain water in the lower parts.

A small pool in which three wells were producing in 1915 has been developed a quarter of a mile north of the center of sec. 20, T. 6 N., R. 11 W. (Montgomery Township), three-quarters of a mile north of the Higgins pool. The oil is derived from a lens in the Robinson sand at 1,115 to 1,125 feet above datum. This is 20 to 30 feet above the level of the oil in the Higgins pool and corresponds closely with that of the upper gas lens in that pool. It is noteworthy that the oil in this small pool is reported to be decidedly lighter than elsewhere in the region, whereas the oil in the Higgins pool is very heavy, testing about 23° Beaumé.

NEW HEBRON POOL

During the first week of July, 1909, the first successful well in the New Hebron pool was completed on the Ida A. Love farm about one-half mile south of the hamlet of New Hebron in the SE. ¼ SE. ¼ sec. 21, T. 6 N., R. 12 W. (Honey Creek Township). This region had been supposed to have been condemned by various dry wells in the neighborhood. The initial production of 25 barrels started a local boom which resulted in the rapid extension of drilling. A large proportion of the first test wells happened to be dry, but a few good wells led to continued drilling and to the rapid opening of the field.

The producing portion of the New Hebron field as now developed covers an area of about two square miles in parts of secs. 20, 21, and 22, T. 6 N., R. 12 W. (Honey Creek Township), and sec. 16, T. 6 N., R. 12 W. (Robinson Township). Of this the western third in sec. 20 and the western half of sec. 21 lies outside the Birds quadrangle.

The pool is due to a distinctly local development of irregular lenses in the Robinson sand. On all sides its limits appear to be determined by a thinning out and disappearance of the sand lenses. Over most of the area two beds of sand are encountered in the wells, the upper at about 1,130 feet, the lower at 1,080 to 1,095 feet above datum (Pl. V, K). Over a small part of the area along the east side of the SE. ¼ sec. 21 the two lenses are merged and form a single thick lens thickened at both top and bottom. In the bottom of this thick sand lens one of the richest producing pools was found (Pl. V, J). Both the lenses are developed in the southeastern part of the pool—namely, in the NE. ¼ SE. ¼ sec. 21, and the SW. ¼ sec. 22. To the south, along the northern line of section 27 the lower bed disappears and only the upper is represented; toward the east the upper lens disappears, but the lower persists for a short distance; toward the north both lenses thin out and in a strip about one-quarter mile in width extending east and west through the center of sections 21 and 22, neither sand is present. In the northern half of the field in the

NE. ¼ and NW. ¼ NE. ¼ sec. 21, and the southern part of sec. 16, Robinson Township, a separate lens (Pl. V, J, Kaley and Van Horn wells) at the horizon of the lower lens to the south yields the oil. This lens is subject to marked local thickening and thinning, as is shown in the profile.

A small lens at about the level of the upper of those described furnished limited production in the center of section 22. Most of the wells in this area were, however, short-lived.

The most striking feature of the oil-bearing sand beds in the New Hebron pool is their irregularity and marked lenticular character. The larger lenses are more even on the top than on the bottom. In the thick sand bed already described along the east side of the SE. ¼ sec. 21, the downward convexity of the bottom of the sand bed is very marked. In fact, the great local thickening of the sand at this point is due mainly to this downward convexity. In the western part of the field the sands are very irregular, but most of the production comes from the horizon of the lower lens.

Underlying the New Hebron field at a level of 1,000 to 1,020 feet is a persistent bed of sand which in most of the wells shows water, but in a few produces oil in small quantities. This water-bearing sand is reported in almost every well of sufficient depth and is recognized in the logs of many of the dry holes outside the limits of the field. It appears to be entirely distinct from and lower than the producing oil sand.

The Robinson sands in the New Hebron pool are free from water.

Gas was found in the majority of the wells, particularly in the upper lens of the Robinson sand. In general, this upper lens produces some gas, and in a few wells a little oil, whereas the lower lens produces mainly oil, and the largest production comes from those wells which lie in the areas where the two lenses are united and the sand is thickest.

There has been no recent development in the main part of the field, but a small amount of drilling has been done in extending the field to the northwest. The field, on the whole, is declining. In the NE. ¼ NE. ¼ sec. 21, in the northern part of the village of New Hebron where a town lot boom resulted in many wells being drilled close together, a majority of the wells have been abandoned and pulled. The close spacing happened to be in a place where the sand is thin and soon led to exhaustion.

There is no indication that the field connects with any other known fields. On all sides the sandstone beds thin out. The pool must, therefore, be looked upon as an isolated group of sand lenses in which the oil has accumulated. There is no evidence whatever that the oil accumulation was governed by a folding or a deformation of the strata.

JACKSON POOL

The small field thus designated covers an area of about one square mile lying mainly in the southern part of sec. 28, T. 6 N., R. 12 W. (Honey

Creek Township), but extending over the line into the northern part of sec. 33 and in a narrow tongue to the southeastward into the NW. ¼ sec. 34, T. 6 N., R. 12 W. Only the eastern half of the field as thus described lies within the Birds quadrangle. This eastern half has been developed very recently—during 1913 to 1915—while the western part, in the Hardinville quadrangle, was developed somewhat earlier. The field produces both oil and gas, but both in small amounts. The initial yield of the wells in the portion of the field within the Birds quadrangle averaged only about 5 to 10 barrels per day. Those in the western half of the field, in the Hardinville quadrangle, averaged considerably higher—from 20 to 50 barrels per day. The gas suffices for pumping purposes. The oil and gas come from a sand whose top lies at elevations between 1,020 and 1,060 feet above datum. The thickness of the sand is very imperfectly known because only a few wells have entirely penetrated it. Many, however, in the central part of the pool have penetrated it from 25 to 40 feet. Toward the southeast the sand is known to thin and pinch out. The oil in most of the wells lies near the top of the sand, and water has been struck in the lower parts in many wells at about 1,000 feet.

The producing sands in this pool lie at a considerably lower level than in the New Hebron pool and are doubtless entirely distinct. From a study of the logs of the wells in the area between the two pools it is concluded that the sand in the Jackson pool is continuous with the lower water sand which is encountered in many of the New Hebron wells at about 1,010 to 1,020 feet and which produces oil in small quantities in some of them. The producing part of the Jackson pool is thought to be conditioned by a local thickening of this sand which brings its top above the general water level. There is a possibility, however, that a local structural dome may be present and may have controlled the accumulation of the oil, but in view of conditions in the other pools, such an explanation seems unlikely. In scattered wells gas is encountered in sands of the level of the producing beds in the New Hebron pool. This is the horizon of the two gas wells in the NE. ¼ sec. 33, both of which stop in this upper sand, and of well No. 3 on the J. D. Highsmith farm in the SW. ¼ NE. ¼ sec. 33, which penetrated to a greater depth but failed to encounter the lower Jackson sands.

WEGER POOL

A small pool about 1¼ square miles in area lies in sections 13 and 18, and adjacent portions of secs. 7, 12, 19, and 24, T. 5 N., Rs. 11 and 12 W. (Honey Creek Township), midway between the Birds and the Parker pools. It is separated from the Birds pool by a strip of unproductive ground only about one-half mile wide, extending north and south through the middle of sec. 18, T. 5 N., R. 11 W.

The oil in this pool, as elsewhere, is produced from the Robinson sand. Nowhere within the quadrangle is the essentially local development of the producing sand more clearly displayed than here. (See profile, Pl. V, L.) At the south end of the pool in the NW. ¼ sec. 19, the sand thins out and disappears; northward it becomes more than 40 feet thick in a distance of only one-quarter mile. The thick sand underlies all the producing territory northward along the line between sections 18 and 13, and the eastern part of section 13. To the east, in the southern part of the field, the sand apparently thins out within a short distance. The boundaries of the thick sand to the west have not been reached, wherefore it appears that the possibilities of further development in this direction have not yet been exhausted. In the northern part of the pool the thick portion of the sand bed lies in the southeast corner of section 12. Eastward from there the sand breaks into two beds the upper of which is locally known as "gas sand" and the lower as the "oil sand". Water is developed in the lower sand at about 1,050 feet. Of the two lenses the upper, or gas sand, is the more extensive and spreads out to the east at least as far as the NW. ¼ NW. ¼ sec. 17, T. 5 N., R. 11 W. (Montgomery Township).

MINOR POOLS IN THE ROBINSON SAND

ALLISON POOL

A small productive pool has been found near the center of sec. 12, T. 5 N., R. 12 W. (Honey Creek Township). The production comes from what appears to be a local accumulation of sand at the Robinson horizon between 1,060 and 1,085 feet above datum. Water fills the sand just below the oil at the general level of 1,050 feet.

CHAPMAN POOL

The completion in November, 1914, of a successful well on the Charles Chapman farm in the NE. ¼ NE. ¼ sec. 3, T. 5 N., R. 12 W. (Honey Creek Township), opened a new field in territory supposed to have been barren of oil. At least five wells had been drilled in this territory previous to the completion of the successful Chapman well, but they had produced only gas or had been dry. Oil seems not to have attracted the attention of the operators even in wells which penetrated to depths as great as or greater than those at which oil was later found in nearby wells.

In general, the new development is due to deeper drilling. The majority of the previous wells tapped only the upper lens of the Robinson sand in which considerable gas was found. The fact that the few wells which had been drilled to depths great enough to have struck the oil in the lower part of the sand failed to strike oil at levels which have later been found productive, must it is believed, be attributed to the irregular, "spotty" character of the sand, though there is a possibility, in some cases at least,

that the gas pressure may have held back the oil, and that after this was relieved by the earlier wells the oil may have migrated to higher levels. The oil comes from the general horizon of the Robinson sand. It is reported in various wells between 1,050 to 1,080 feet. The sands appear to be notably irregular, both in thickness and in areal distribution. The available records are so few and show so great irregularity that a more detailed statement of conditions can not be made.

The field was being actively extended during the latter part of 1914 and the summer of 1915. By September 1, 1915, there had been completed 15 productive wells.

SWEARINGEN GAS POOL

A small pool which produces gas from sand at the Robinson horizon has been found near the Swearingen Chapel at the common corner of secs. 17, 18, 19, and 20, T. 6 N., R. 11 W. (Lamotte, Honey Creek, and Montgomery Townships). The principal part of the pool is in the SE. ¼ sec. 18, and the SW. ¼ sec. 17, Lamotte Township, on the F. G. Swearingen farm. The area covered is somewhat less than one-half square mile. The wells produced gas in considerable quantities, but the majority of them lasted only two or three years. Only 6 of the 12 original wells were producing in the summer of 1915. The sand is found between 1,050 and 1,080 feet above datum. Only the upper 10 or 20 feet has been penetrated because salt water is thought, and in at least one case has been proved, to lie below.

A few scattered wells, all now abandoned, tapped gas sand at the Robinson level in secs. 8 and 9, T. 6 N., R. 11 W. (Lamotte Township), at elevations ranging from 1,056 to 1,081 feet. The wells are too far apart for detailed correlations.

Relation of Pools in Robinson Sand

The four principal productive pools are the New Hebron, Flat Rock, Parker, and Birds. These pools are almost if not entirely separated from each other. Each has as its essential nucleus a continuous thick bed of sand of considerable extent, which, in general, thins out or becomes lenticular along the margins and in irregular outliers.

That the formations which yield oil in the larger pools are not present, or are very much thinner in adjacent unproductive territory is shown very clearly by the logs of many of the dry wells on the borders of the pools. This feature is illustrated along the southeast side of the Parker pool, the south side of the Birds pool, and the south end of the Weger pool.

The smaller productive pools, such as the Weger, Allison, Jackson, and Chapman, lie at about the same level as the larger pools, but are entirely distinct from them or at most connected with them only by thin,

unproductive beds of sand which are both thinner and lower than the productive beds in either the larger or the smaller pools.

The character of the thin beds between the larger pools is graphically shown on the stereogram (Pl. VI) of the area between the Birds and the Weger pools. Here the producing sands are thin and low and are remarkably uniformly bedded as compared with the thick sand masses which constitute the main pools. That most of the wells pass entirely through the sands into the underlying shales is definite proof of the thinness of the sand beds.

The sand formations in the minor pools are, in general, irregular as compared with the larger sand masses of the Birds, Parker, Flat Rock, and New Hebron pools. This is notably true of the Jackson, Chapman, Allison, and to a less extent of the Weger pool. A similar irregularity is also characteristic of the outliers of the main sand masses, such as the western end of the Parker pool and the outlier northwest of the Parker pool in sec. 9, T. 5 N., R. 12 W. (Honey Creek Township); the outlier of the Birds pool in secs. 8, 9, 16, and 17, T. 5 N., R. 11 W. (Montgomery Township); the extreme eastern end of the Birds pool; and the eastern end of the Flat Rock pool.

The scattered test wells in the areas between the producing pools show so great irregularity in the sands that correlation between wells one-half mile or more apart is almost impossible. In many of the wells no sand occurs at the Robinson sand horizon, whereas in others the sand is present but unproductive, in some places being filled with salt water.

Summarizing the foregoing, it may be said that the accumulation of oil occurs where the Robinson sand is thick and massively developed and seems to have been conditioned by this feature; and that between the known producing areas the sand where tested has proved spotty or is absent. (This statement should not, however, be taken as implying that productive pools may not be found in the areas between those now known.) No apparent relation to geological structure other than this has been discovered. The producing sands lie at approximately the same elevation everywhere within the quadrangle, and it is a more plausible explanation that whatever differences in elevations there may be are due to irregularities in the deposition of the sands than that they are due to differences in folding or arching of the strata. Any differences due to arching are certainly less in amount than the known differences in elevation due to the irregularities in the sand lenses, and therefore, even if present, can not be detected with certainty.

Probable Mode of Origin of Robinson Sand

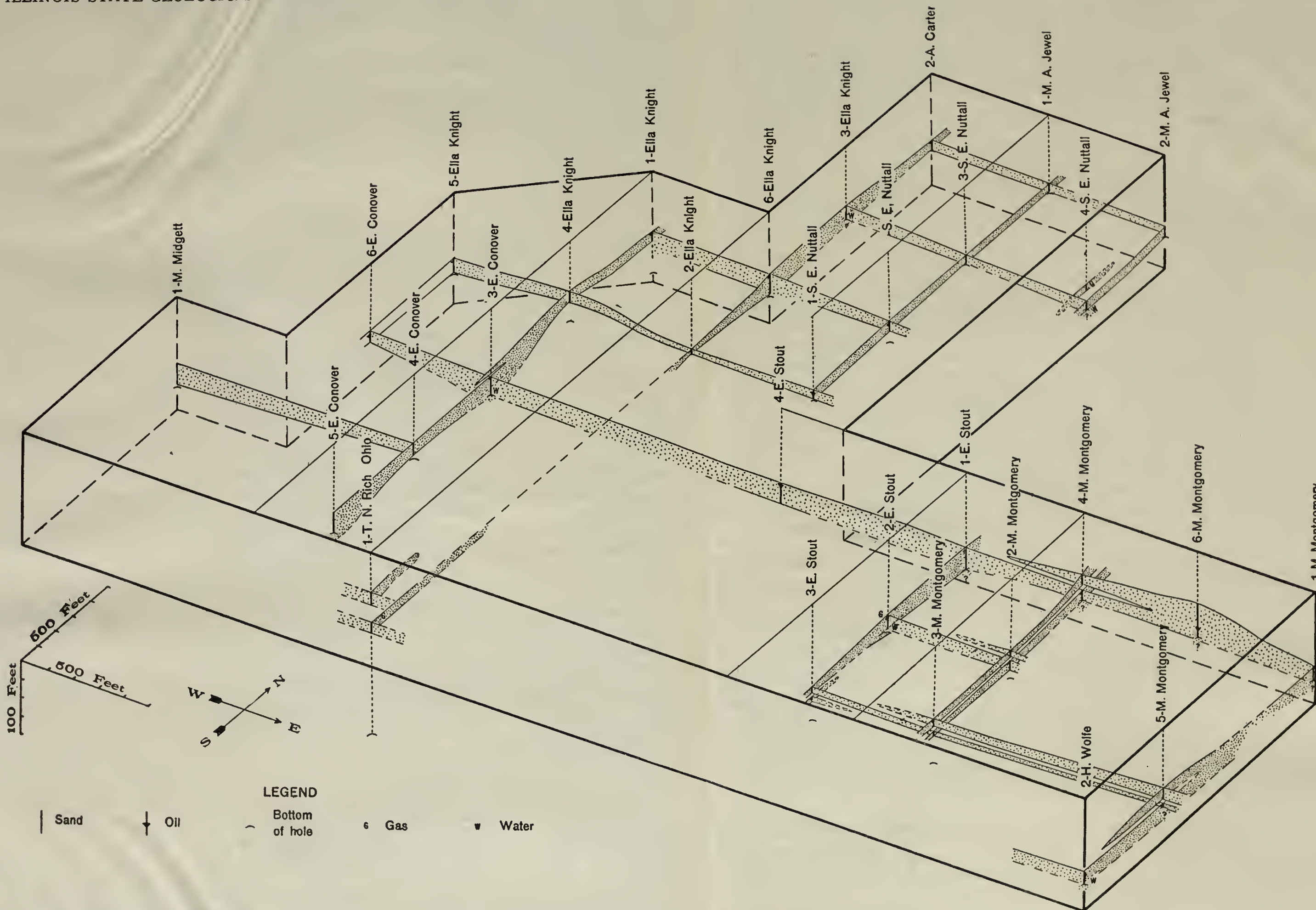
For areas in which wells are not more than one or two locations (400 to 1,000 feet) apart, the logs or driller's records of the wells, though in many cases not so detailed as might be desired, nevertheless yield sufficient

data for a fairly satisfactory study of the oil sands. Particularly is this true regarding records of wells that pass entirely through the sand into underlying formations. The oil sands in each of the pools studied by means of these logs, have been described in detail on the preceding pages. It is here proposed to inquire more fully into the question of the origin of the sands which constitute the producing beds. Because sand beds have different structural and textural characteristics and different types of distribution corresponding with various modes of origin, a knowledge of the origin and the mode of deposition of the sand formations involved in a particular oil-producing area is of the greatest importance to the geologist or to the oil operator who may desire to locate new territory or to attempt the extension of the old fields. As an illustration of the preceding statement, it might be pointed out that sand beds spread out over the ocean bottom by waves have very different characteristics and areal extent from sands deposited by rivers on deltas or in river channels. Prediction as to the extension of known fields which might be perfectly safe when applied to sands of the former type would be utterly worthless if one were dealing with deposits made under the latter conditions. The problem of the origin of the sands has therefore a very distinct and important practical bearing.

The available data on the sands of the Birds quadrangle, presented in the following paragraphs, is believed to be sufficient to shed much light on the problem of their origin. By way of caution it should be pointed out that the accuracy of the results must of course depend on that of the well records used, and that where these are in error or were carelessly recorded, peculiar structures may appear in the profiles which are not present in nature. A feature, however, which is consistently recorded in the logs of several adjacent wells may be accepted with assurance.

It is conceivable that an oil-bearing formation like the Robinson sand, may have been deposited in any one of the following ways, or in combinations of two or more of them: (1) spread out by waves and currents over the sea bottom, (2) deposited in the form of basal conglomerate by the waves of an advancing sea, (3) thrown up by waves a short distance off shore in the form of off-shore bars such as are now in process of formation along the Atlantic and Gulf coasts of the United States and Mexico and along other low sandy coasts, (4) deposited by rivers on a land surface or in very shallow water in which wave-action was weak, (5) deposited by rivers on the surface and on the front of a delta and in part re-worked by waves and currents into bars and beaches or spread out over the adjacent ocean bottom. If formed by methods 3, 4, or 5, portions of the sand might be worked over more or less by winds and possibly heaped up into sand dunes.

The testing of the preceding hypotheses for the Robinson sand may perhaps best be accomplished by considering in detail the logical conse-



Stereogram showing characteristics of oil sand in Birds quadrangle

quences of each according to the well-known principles of geology and physiography, and by comparing these deduced consequences with the features exhibited by the formation under discussion. In this way, by a process of elimination, the problem may be narrowed down to only a few possibilities.

1. *Sands spread out over the sea bottom by waves and currents.*—Sand deposits made in this manner should lie in beds of great uniformity of elevation over considerable areas. In general there should be a gradual slope toward the former open sea, interrupted by only minor irregularities of a broad type. The resulting sand beds should be uniform and persistent over areas not uncommonly many times greater than that of the entire Birds quadrangle.

From the descriptions of the occurrence of the Robinson sand it is clear that it is not of this type. Its very pronounced irregularity from place to place, its marked lenticular character, and the great variation in its top surface are all out of harmony with such an explanation. It may, therefore, be discarded as inadequate for the formation as a whole, though it may apply in a limited way to certain areas such as that between the Weger and the Birds pools, shown on the stereogram (Pl. VI).

2. *Beach deposits of an advancing sea (basal conglomerates or basal sandstone).*—When on account of a rise in ocean level or a sinking of the land, the sea advances over a land surface its waves attack the land and strew the debris in the form of gravel and sand along the shore and out over the adjacent ocean bottom. As the sea advances the coast line is pushed farther and farther inland. Meanwhile as the water becomes deeper the sand and gravel which marked its former shore becomes buried under finer material. In similar manner the basal sandstone or conglomerate is spread out over the entire area over which the sea transgresses. Such a conglomerate, according to Ulrich[6], is not in all cases continuous over the entire area of transgression and may vary considerably in composition, but it should at least have a very uniform top, for that surface is determined by the action of the waves in open waters.

Applied to the Robinson sand this hypothesis meets with the same objection as the previous one—namely, the great irregularity of the sands, their lack of continuity, and their uneven top surface. Furthermore, there is no apparent reason why a basal conglomerate should lie in channels extending down into the underlying beds as do the sands in several places in the region under consideration.

3. *Off-shore bar and lagoon deposits.*—Along a shelving coast the sea throws up long off-shore bars of sand such as are now forming along the Atlantic and Gulf coasts of the United States. Behind the bars are

[6]Ulrich, E. O., Revision of the Paleozoic systems: Geol. Soc. America Bull., vol. 22, pp. 454-456, 1911.

sheltered lagoons which are slowly being filled up by mud and sand in part derived from the land, in part washed in over the bar at times of storm. At varying intervals the bars are broken by inlets through which the tides have access to the lagoons. Such off-shore bars are not uncommonly hundreds of miles in length, though broken at intervals by inlets. In width they vary from one-fourth mile to five miles or more. They are composed of sand heaped up by the waves but modified on the surface by winds and not uncommonly piled up into sand dunes. On the ocean side the sand of the bar is continuous with that spread out over the ocean bottom by the waves. On the landward side are the muds and sands of the lagoons. If a bar is pushed landward by the waves as the lagoon fills up, the sands of the bar transgress over the mud of the lagoon at higher and higher levels and a deposit is formed which in section is illustrated in figure 10, drawn to represent conditions as they would be if the waves

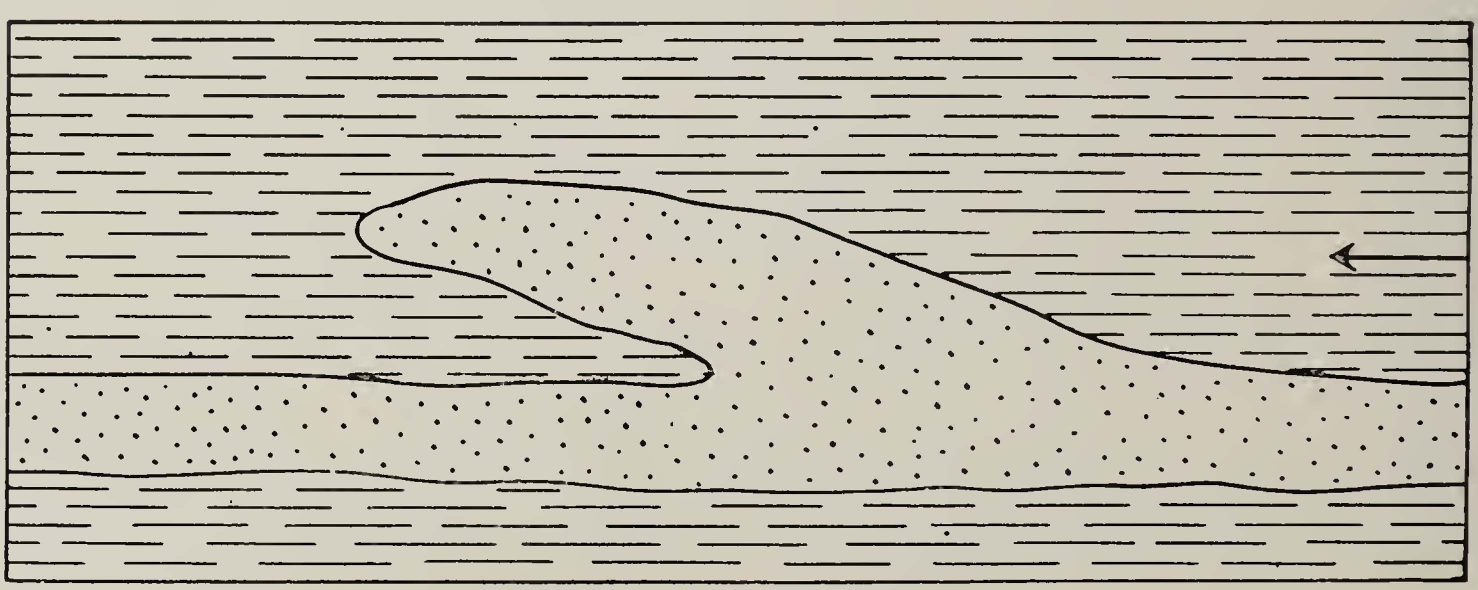


FIG. 10.—Diagrammatic cross-section of sand-bar deposits.

were pushing the bar from the right to the left, and if the whole later became buried in mud. At the inlet the tides scour effectively and not only maintain a channel but scour down from 50 to 100 feet, making a deep hole at the narrowest part of the inlet. Opposite the inlet a delta-like heaping up of the sand takes place on the oceanward side of the bar. All these features are very clearly shown on the United States Coast and Geodetic Survey charts. At the inlets the end of the bars are turned inward, or landward, in a very characteristic manner, as shown in figure 11, a sketch of such an inlet taken from one of the U. S. Coast Survey charts and here reproduced for comparison.

From the above description it is apparent that many points of similarity exist between the features of the Robinson sand and those characteristic of off-shore bars now in process of formation. A closer comparison emphasizes this similarity. Each of the three larger oil pools—the Birds, Parker, and Flat Rock pools, are composed of massive beds of sand. Both the Flat Rock and the Birds pools are notably linear in extent and nearly

Fig. 11.—Map of Barnegat Inlet and Bay.

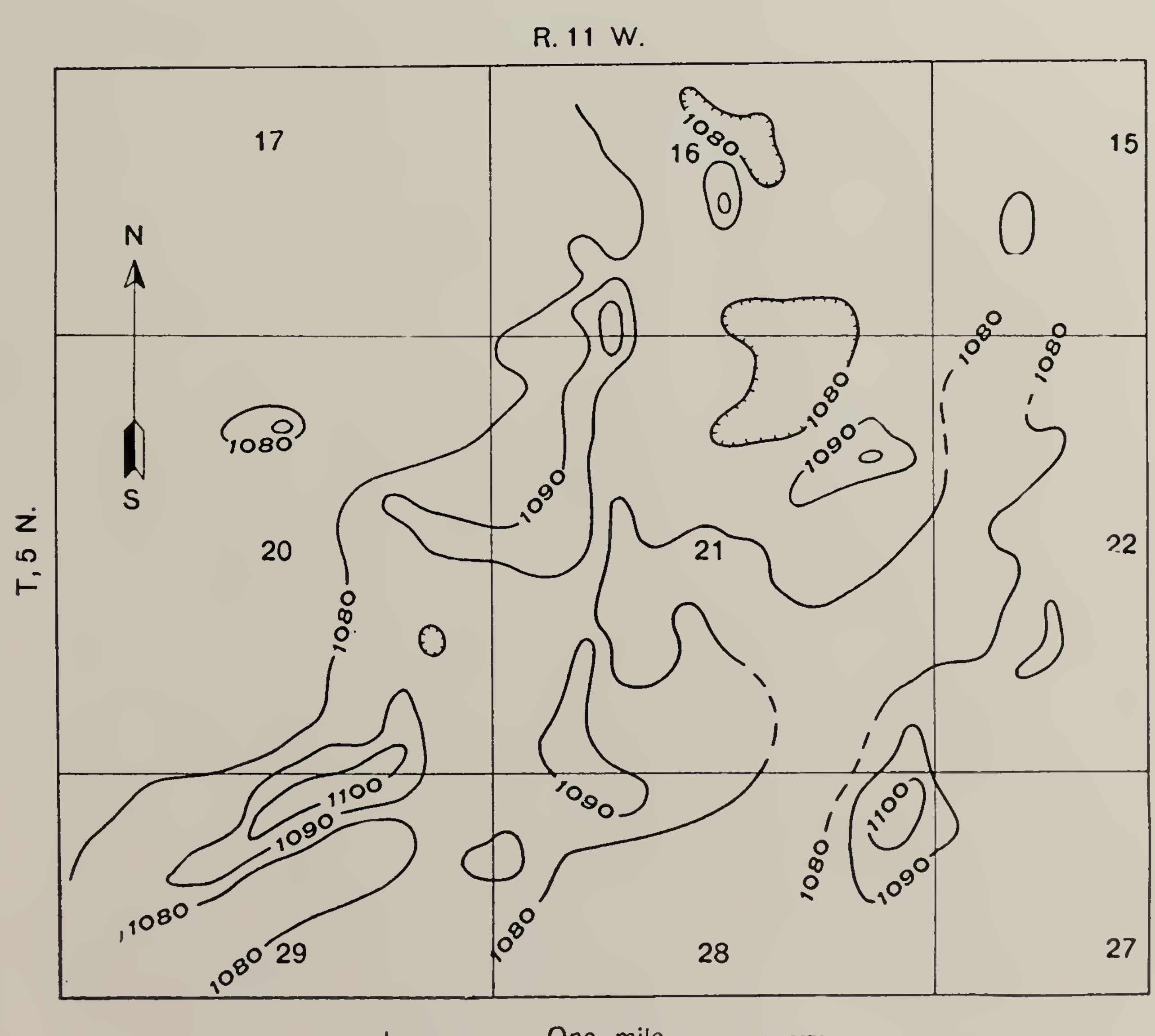


Fig. 12.—Contour map showing surface form of Birds pool sand.

parallel to each other. The Parker pool, though not linear in outline, is in line with the Flat Rock pool. The surface of the southern part of the Flat Rock pool is marked by undulations parallel to the length of the sand mass, a feature strikingly in harmony with the bar theory. The surface of the sand in the Birds pool is marked by narrow, curving ridges (Fig. 12) which bear a remarkable resemblance to the sand formations at the inlets which interrupt the continuity of the sand bars on modern coasts (Fig. 11). The minor ridge of sand which constitutes the southeastern margin of the Birds pool has already been noted. It is distinctly a long, straight ridge or reef of sand. Its structure, furthermore, is notable in that it presents outfingering sand lenses of a type shown in the sketch (Fig. 10) directed toward the northwest, thus indicating open water to the southeast. The general upward convex profile of the top of the sand beds is, according to Barrell[7], further indication, though not necessarily proof, that they are wave formed. The dune-like mounds on the surface of the sands in the northeastern part of the Parker pool are in harmony with the bar theory as is also the regular, relatively steep descent of the southeastern border of the sand mass, in case, as is indicated by the reef at the southeastern margin of the Birds pool, the open sea lay to the southeast.

Notwithstanding the many points of agreement between the phenomena under discussion and those which should be expected under the bar theory, certain features seem to show that, at least for the minor pools, some modification of this explanation must be sought. The objections are: (1) that the sand masses are too small and too discontinuous to be compared strictly with the great off-shore bars now forming on the coasts of the open ocean; (2) the minor pools have the characteristics of channel deposits such as are formed by rivers, rather than sea-bottom deposits or bars; (3) they are too irregularly distributed for open-water deposits. Some explanation must therefore be found which is in harmony with these characteristics as well as with those of the larger sand bodies which constitute the major pools.

4. *Sands deposited by rivers on the surface of the land either in channels or on the tops of deltas.*—River channel deposits are characterized by the greatest irregularity both in form and in composition. This irregularity is due to the constant shifting of the channels and to the variable character of the sediment load carried by the river. In general river-deposited sand should lie in more or less regular, braided, linear belts. Such deposits differ from those formed on the ocean bottom in that they habitually cut down into the underlying beds and are convex downward on the under side, whereas the top surface may or may not be convex upward. This feature, together with very great irregularity, may be taken as the most characteristic of river deposits. An examination of the cross-

[7]Barrell, Joseph, Criteria for the recognition of ancient delta deposits: Geol. Soc. America, Bull. vol. 23, pp. 428, 433, 1912.

section profiles of the sands in the various pools reveals the fact that they not uncommonly cut down into the underlying beds and are convex downward. This is particularly true in the New Hebron and the Weger pools. On the other hand, the large sand masses which compose the Birds, Parker, and Flat Rock pools with their upward convex and ridged surfaces, are not readily explained as purely river-channel deposits.

The various sand beds seem therefore to possess characteristics of a mixed order, some peculiar to river deposits, others to those of wave-worked sea bottom and sand bars.

A recognition of this complexity leads directly to a consideration of the fifth of the proposed hypotheses; namely, that:

5. *The oil-bearing sands may be part of a great delta formation in which are combined river-channel deposits, off-shore sand bars thrown up by the waves along the front of the delta, and wave-worked sands spread out over the adjacent ocean bottom.*—The present deltas of the earth where exposed to wave action are much modified along their margins by the waves. The materials supplied by the rivers are picked up and strewn along the coast by waves and currents and built up into sand bars which differ, however, from typical off-shore bars in that they are smaller and more irregular and furthermore, in that the constant building out of the delta front causes new bars to be thrown up at intervals outside the older ones, thus producing a more or less parallel series of discontinuous sand bars, the inner and older of which are protected from wave erosion and, in the normal course of events, are finally buried under delta deposits and preserved intact. On the modern deltas, irregular shifting of the distributary streams constantly alters the form of the delta front; incloses lakes here and there by building out irregularly; fills others with sand; and gives rise to numerous channel deposits in the upper beds of the delta.

Thus on modern deltas are found in appropriate proportion, all the features described as characteristic of the Robinson sand as determined from the well records. Such an explanation harmonizes the bar-like form of the larger sand masses with the channel features and the irregularity of certain of the smaller pools and with the even, thin sand beds of such outliers as that shown in the stereogram (Pl. VI), near the corner of secs. 17, 18, 19, and 20, T. 5 N., R. 11 W. (Montgomery Township). According to this explanation the Flat Rock and Parker pools are sand bars, probably of the same age; the Birds pool is a larger bar parallel to the first and built presumably at a later time farther off shore. The smaller and more irregular pools may be river-channel deposits, portions of a delta top or front; smaller, more irregular bars, or lagoon delta deposits formed opposite the mouths of tidal inlets. The deep channels revealed in the southern parts of the New Hebron and the Weger pools may be deep

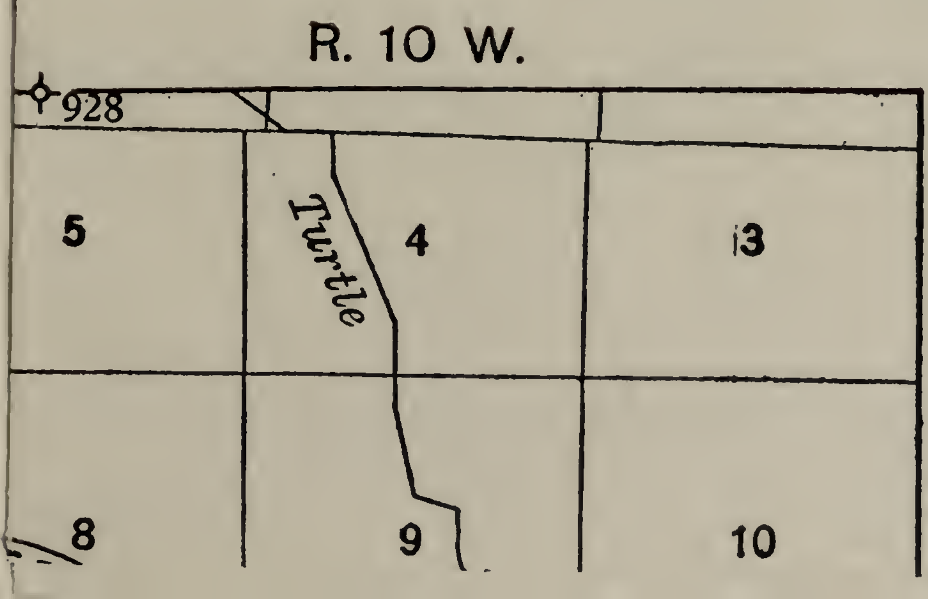
river channels or possibly deep basins analogous to those produced by tidal scour at the inlets which interrupt the continuity of sand bars.

If the Robinson sand formation has originated in this way, the sands between the reefs should be expected to be thin or absent and to lie at levels several feet lower than the sands of the same age in the reefs. These inter-reef areas should have been filled on the lagoon side with mud and irregular lenses of sand; on the ocean side by more evenly distributed sand or sandy mud. The conditions actually found in the areas between the reefs, in so far as they have been explored by the drill, meet these expectations.

Since the distribution of the formations at the horizon of the Robinson sand, as revealed by the well records, corresponds very closely with the conditions found in connection with modern deltas built into seas in which waves are moderately active it is believed that such an explanation of the origin of the rocks of this horizon accords best with the observed facts. Certain characteristics of the sand beds indicate that the delta was built out from the northwest, and that the open sea lay to the southeast when these deposits were being laid down in upper Pottsville time.

Prospects of Further Oil Development in Robinson Sand

Since the productive areas are dependent on the presence of local thick masses of sandstone, and since the formations involved seem to be deltas and sand reefs (formations which are notable for their irregularity), it is clear that no safe prediction of the presence or absence of oil-bearing sands can be made in advance of drilling. Where structure alone controls the distribution of the oil, the geologist, by studying the structure of the overlying rocks, is often in a position to predict new developments, but he is helpless where the presence or absence of lenticular sand is the determining factor which governs the accumulation of the oil. For these reasons no attempt is made to outline other areas within the quadrangle which might be found productive. Instead a map (Pl. VII) has been prepared to show the areas in which the horizon of the Robinson sand has been tested and the location and depth of scattered wells which have penetrated deep enough to test this sand. Owing to the "spotty" character of the producing sands, it should be borne in mind, however, that no area may be condemned until it has actually been tested by a reasonable number of wells. Several of the smaller pools are of such local extent that they might readily have been missed even by moderately close wildcat drilling. Even pools as large as that at New Hebron might readily have been overlooked. In fact, after the first successful well was drilled, the next two or three to be completed proved dry, and it was only by persistence that the field was finally developed. In the absence of test holes there is nothing to indicate that any part of the quadrangle might not prove productive, whereas on the other hand there is nothing to indicate the


R. 10 W.
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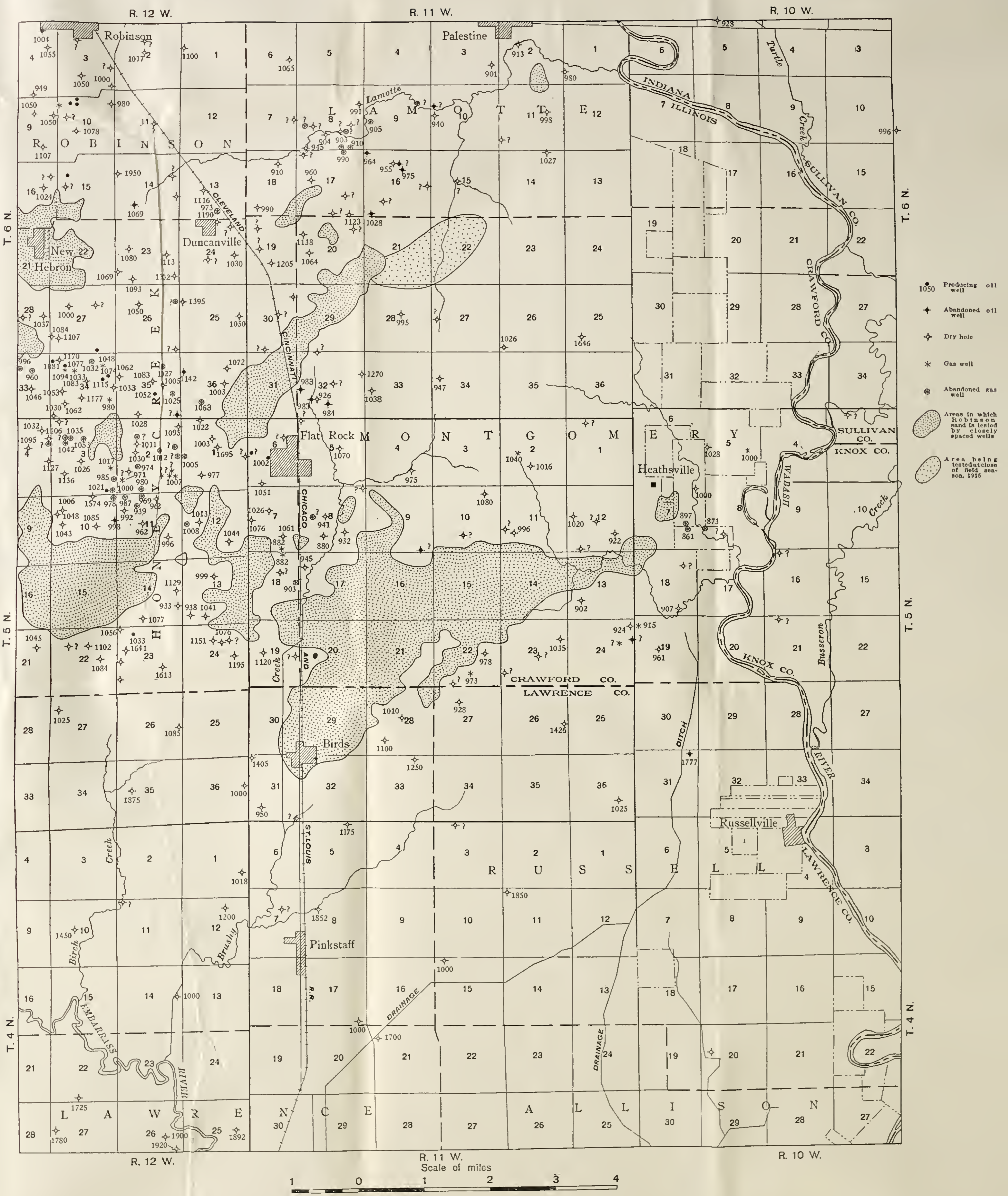

Map showing drill holes to Robinson sand in Birds quadrangle

reverse. Should a successful wildcat well be found, it is believed that a second well on an adjoining location would be more likely to be successful than one one-half mile or more distant, because the latter might be entirely outside the productive area.

In connection with the description of the various pools certain places were mentioned where it seems that the possible productive territory has not been entirely drilled. Among them may be mentioned the extreme southwestern end of the Parker pool and the west side of the southern half of the Weger pool. It is also possible that the main linear pools may be found to continue beyond the limits now known.

Character of Oil

The oil from the Flat Rock pool, particularly from its eastern end, is noted for its high specific gravity. The gravity increases toward the eastern end of the pool where it is as high as 22.3° Beaumé[8], as compared with 35° Beaumé for the oil from the Hardinville quadrangle ten or twelve miles to the west. In the Weger pool, also, marked differences in gravity have been noticed. Mr. Claud Duffy operating in the Weger pool is authority for the statement that along the north line of sections 19 and 24, Honey Creek Township, the oil becomes lighter as one passes from east to west, testing 28° or 29° Beaumé in the northwest corner of section 19 and 34° Beaumé in the Nuttall wells in the NW. ¼ NE. ¼ sec. 24. The change is first noticed in the J. O. Weger well No. 3. A geologic profile along this line (Pl. V, M) brings out the fact that at the eastern end where the oil is heavy the oil sand is thick at the top and is overlain directly by a gas sand. Farther west where the light oil occurs the oil sand is separated from the overlying gas sand by 18 feet of very compact, hard, blue shale ("slate") and by about 14 feet of gray, micaceous sandstone. Near the point where the change in gravity is noticed the oil sand becomes very thin—only about 2 feet thick. Thus the two areas are partially, though probably not entirely, disconnected. Similarly in the eastern half of the Flat Rock pool there is a gas sand above and directly connected with the oil sand. These relationships suggest the theory that the cause of the heavy oil is the evaporation of the lighter constituents and their escape into the overlying gas sands, leaving behind the heavier residue. A profile section along the axis of the Flat Rock pool (Pl. V, I) was drawn for the purpose of testing the theory that the heavy oil at the eastern end of the pool might be due to a rise of the axis toward the west and a migration of the lighter oil toward the higher structures and of the heavier oil toward the lower eastern end. The section, however, reveals the fact that the axis of the productive pool is highest in the center and near its eastern rather than its western end. There seems to be no basis for the belief that

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[8] Day, David T., Analyses of petroleum from various parts of the United States: U. S. Geol. Survey Mineral Resources, 1913, pt. 2, p. 1,182, 1914.

the differences in gravity are due to migration along the axis of the pool. It seems still less likely that the lighter oil has migrated entirely outside the limits of the pool to the region of lighter oil in the Hardinville quadrangle to the west, since there is apparently no connection between the Flat Rock pool and those farther west.

In this connection it is significant that the oil from the relatively high sand in the small pool a quarter of a mile north of the center of sec. 20, T. 6 N., R. 11 W., is relatively light, also that in certain places in the Hardinville quadrangle heavy oil occurs in certain lower sands recently discovered while the oil in the upper sands is light. A detailed field study of the gravity of the oil promises results of value if correlated with the geological conditions in each case.

Salt Water Phenomena

An investigation of the water phenomena of the oil sands was undertaken in the hope that it might reveal the broad relationships between the extent and depth of water saturation and the distribution of oil and gas in the sands. Over the entire quadrangle water-bearing sands are encountered at various levels above the Robinson sand. Of these higher water sands the most conspicuous is the heavy, locally gas-bearing sand which lies between 1,300 and 1,430 feet above datum. The data at hand do not permit description of the water conditions in these higher sands.

The data for each pool in the Robinson sand are here presented in summary form. In the western and central parts of the Birds pool the line of saturation appears to lie very uniformly at about 1,050 feet above datum, as is indicated by the uniform depth of the wells and by definite mention of water in several of the logs. In the eastern and southeastern parts of the pool the line of saturation stands 10 to 15 feet higher—namely, at 1,060 to 1,065 feet above datum. For the extreme eastern end of the pool in sec. 7, T. 5 N., R. 10 W., no data are at hand.

In the Weger pool the water lies at various levels between 1,030 and 1,050 feet. The general average for the pool is 1,040 to 1,045 feet. Between the Weger and the Birds pools the outlier in secs. 17, 18, 19 and 20, T. 5 N., R. 11 W., shows water only in the bottom of certain low places in the base of the sand at elevations of about 1,040 feet.

In the main body of the Parker pool the water level is more or less uneven. In general it lies between 1,035 and 1,050 feet. In detail it seems to be controlled by some factor other than hydrostatic pressure, for at the southeastern side of the pool the level of the water line descends almost parallel to the top of the sand. The lenticular western end of the Parker pool and its outlier in sec. 9, T. 5 N., R. 12 W. (Honey Creek Township), show water in the bottom of the lenses at various levels. The indications there are that each lens is independent of the others.

In the Flat Rock pool there is considerable difference in level between different parts. In the main body of the southern end of the pool, northwest of Flat Rock, the water line lies at 1,060 to 1,065 feet. In the narrow middle portion, near the SW. cor. sec. 29, T. 6 N., R. 11 W. (Montgomery Township), it is about 1,060 feet, but in the Higgins pool near the NE. cor. sec. 29, and SE. cor. sec. 20, T. 6 N., R. 11 W. (Montgomery Township), the elevation is 1,072 to 1,075 feet. A short distance farther east on a low terrace on the A. M. Welch farm in section 21, the water lies at 1,040 to 1,045 feet. Evidently there is not free connection between the sands on the Higgins farm and either those on the terrace to the east or those in the main part of the Flat Rock pool to the southwest. Of the smaller productive areas, the Swearingen pool at the common corner of secs. 17, 18, 19, and 20, T. 6 N., R. 11 W., shows only gas, and no water is reported in the logs. The wells end 5 to 15 feet below the top of the sand. One of the wells struck a show of oil at 1,044 feet above datum but was shot into water and abandoned. It appears therefore that the water level there is about 1,040 feet and that there is a little oil on the top of the water. In the Allison pool, sec. 12, T. 5 N., R. 12 W., the water is found at various levels ranging from 1,045 to 1,070 feet. The majority of the wells show water at about 1,055 feet. The wells in the Chapman pool yield no reliable data on the water problem. It appears, however, that at least above 1,050 feet no water is present in the sands.

The Jackson pool is remarkable in that the water level is considerably lower than elsewhere, and that most of the oil is produced from levels below that of water saturation over the rest of the quadrangle—namely, 1,030 to 1,040 feet. The water level, as recorded in the records of the Jackson pool, lies between 995 and 1,021 feet above datum. In the majority of the wells it is very close to 1,000 feet.

The New Hebron pool appears to be underlain by water-bearing sand at 985 to 1,030 feet above datum wherever wells have penetrated to this depth. This water, however, is in sand 30 to 50 feet below that which produces the oil. The oil sand appears to be entirely dry. Only in the western part of the pool where the sand lenses are notably irregular was water reported at an elevation of 1,063 feet in the bottom of one of the sand lenses. That this occurrence was governed by the local lens in which it appeared, is indicated by the fact that this water lay 15 feet above gas and oil in wells about 1,500 feet distant.

As a generalized statement it may be said that the level of water saturation in the Robinson sand within the Birds quadrangle is approximately 1,050 feet above datum, or 450 feet below sea level. The water level is not the same in all pools nor in all parts of a single large pool, such as the Flat Rock or the Birds pools. In different pools the general level ranges from 1,000 feet to 1,075 feet above datum. It appears, therefore, that

whereas within this range there may be said to be a general level of water saturation, there is considerable irregularity. This feature, as also the distribution of the oil sand, indicates that the various pools are to a greater or less extent independent of one another. Between the producing pools, test wells encounter water at various levels between 1,050 and 960 feet above datum. No general rule for its occurrence is, however, apparent.

Relation of Water Conditions to Origin of Oil

Since the two independent lines of evidence outlined above agree in indicating that there is little if any connection between the different pools, it appears that the oil could not have migrated very far laterally under the influence of salt water. Migration for long distances up the dip of the rock toward the higher structures, as urged by Blatchley[9], is difficult to comprehend in cases like that under consideration in which there appears to be no continuous bed of sand up which the oil could have migrated. The observed relations of the sands to each other and to the level of salt water in the various pools seems to the writer to suggest strongly that the oil has not migrated for any great distance laterally, whatever may have been the extent of its vertical migration. Furthermore, the presence of both oil and water in small local lenses apparently disconnected from other oil-bearing sands seems likewise to point to the conclusion that the oil has not migrated, at least laterally, for any great distance.

DEEP WELLS

Locations

On the map (Fig. 13) are shown all the wells which are known to have been drilled deep enough to test the lower sands which have been found productive in neighboring quadrangles. In the Birds quadrangle no successful deep wells have as yet been drilled, though a well on the Lagow farm, secs. 31, T. 5 N., R. 10 W., drilled in the spring of 1916, produced the first day 14 barrels of oil from the McClosky horizon. The well later developed much water and was abandoned. In several wells, however, a showing of oil or gas has been found. These are listed below, and the horizon of the oil showing is indicated.

1. W. T. Highsmith, NW. ¼ sec. 14, T. 6 N., R. 12 W., at 470 feet above datum (Tracey or McClosky).
2. Wash Parker No. 7, NE. ¼ sec. 3, T. 5 N., R. 12 W., at 495 feet above datum. (In this well there was a show of oil with gas 100 feet below the top of the Chester, 50 feet above the top of the "Big Lime". The horizon is probably Tracey.)
3. E. A. Young No. 1, NE. ¼ sec. 10, T. 5 N., R. 12 W., at 551 feet above datum (Chester).

[9] Blatchley, R. S., Oil in Crawford and Lawrence counties: Ill. State Geol. Survey Bull. 22, p. 104, 1913.

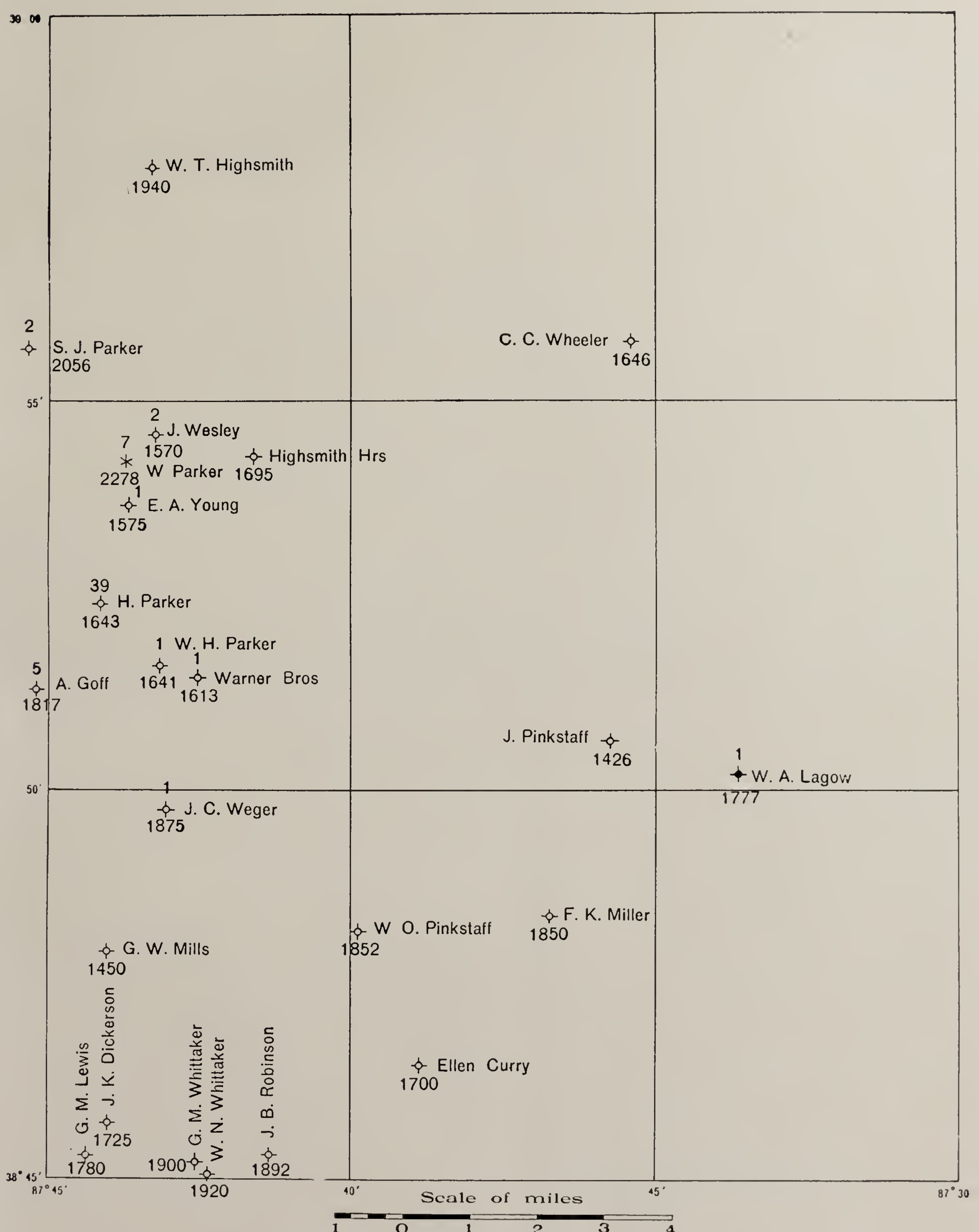


FIG. 13.—Map showing wells which penetrate Mississippian rocks.

4. John Wesley No. 2 NW. ¼ sec. 2, T. 5 N., R. 12 W., at 550 feet above datum (Chester).
5. S. J. Parker No. 2, SW. ¼ sec. 28, T. 6 N., R. 12 W., at 487 feet (probably Chester). There was also a show of green oil in limestone at –22 feet or 2,030 feet below the surface (St. Louis).
6. W. O. Pinkstaff, NW. ¼ sec. 8, T. 4 N., R. 11 W., Bond Township, at 258 feet. (Some oil in sandy lime: McClosky.)
7. W. A. Lagow, NE. ¼ NE. ¼ sec. 31, T. 5 N., R. 10 W. (Russell Township), a 14-barrel well (later abandoned). Oil at 338 feet above datum (McClosky).
8. F. K. Miller, NW. cor. sec. 11, T. 4 N., R. 11 W.; a showing of green oil at 326 feet above datum (McClosky).

Structure of Lower Beds

Since there are few wells deeper than the Robinson sand horizon in the Birds quadrangle, the discussion of the structure of the deeper rocks is based on a small number of records. The available data indicate that a comparatively sharp monocline, extending southeastward from the western edge of the map at about latitude 38° 50′ to near the center of the south line of the quadrangle, separates a low basin on the southwest, occupying all the southwestern corner of the quadrangle, from a relatively high, nearly flat area which occupies all of the quadrangle north and northeast of the monocline. This monocline is without doubt a continuation of the one recognized in the Hardinville quadrangle as bounding the Robinson oil pool on the west.

The facts on which the preceding summary statement of the structure is based are as follows: In the southwestern corner of the quadrangle at least 6 deep wells have been drilled. In one of these, the Dickerson well, near the south center of sec. 22, T. 4 N., R. 12 W., a sand, probably the Kirkwood lying beneath two beds of red shale was encountered at a depth of 240 feet above datum, or 1,260 feet below sea level. The well ended in sand at 1,300 feet below the sea. Another well (J. B. Robinson, log published herewith on a previous page) in the SW. ¼ NE. ¼ sec. 25, T. 4 N., R. 12 W., penetrated to a depth of 1,892 feet, or 23 feet above datum, and ended in a sand probably Kirkwood. The top of the Ste. Genevieve formation, or "Big lime", was not reached in either well.

To the north of the assumed line of monoclinal folding, every well of which a record is available penetrated the "Big Lime" at elevations between 378 and 475 feet above datum. The locations of these wells with the elevations above datum of the top of the "Big Lime" (Ste. Genevieve) are tabulated below. The first in the list is only 3¾ miles north of the well in section 25 already mentioned (J. B. Robinson), which at 23 feet above datum was still above the Ste. Genevieve.

1. NW. ¼ sec. 8, T. 4 N., R. 11 W., W. O. Pinkstaff, 378 feet above datum.
2. NW. cor. sec. 11, T. 4 N., R. 11 W., F. K. Miller, 412 feet above datum.

3. NE. ¼ NE. ¼ sec. 31, T. 5 N., R. 10 W., W. A. Lagow, 443 feet above datum.
4. SW. cor. NE. ¼ sec. 3, T. 5 N., R. 12 W., Wash Parker, 460 feet above datum.
5. NW. ¼ sec. 14, T. 6 N., R. 12 W., W. T. Highsmith, 475 feet above datum.

These figures indicate that north of the monocline, the Mississippian rocks lie approximately flat; but have a slight dip toward the east or southeast. As has already been shown, the data yielded by the wells which penetrate the Robinson sand in the Birds quadrangle prove that sand to lie essentially flat over the entire northern two-thirds of the area. Inasmuch as the surface rocks reveal only slight irregularities in structure, whereas the Mississippian rocks show differences in elevation of over 400 feet in the southern part of the quadrangle, the existence of a great unconformity between the two is very clearly indicated.

The absence, in the wells which reveal the "Big Lime" at elevations of 400 feet or more above datum or recognizable representatives, of any but the basal rocks of the Chester group indicates that the major unconformity is between the top of the Mississippian series and the base of the Pennsylvanian series. This interpretation harmonizes with the evidence of unconformity at this horizon yielded by the fact that south of this area in the southern part of the Vincennes quadrangle, the thickness of the Chester beds occupying the interval between the "Big Lime" and the base of the Pottsville increases, wedge-like, toward the south.

Oil Possibilities of the Deeper Rocks

North of the line of monoclinal folding mentioned in preceding paragraphs, the Mississippian rocks seem to lie high and comparatively flat. As explained above, the data at hand indicate that the upper beds of the Chester group are missing. If this interpretation is correct, the Kirkwood sand, one of the most persistent and reliable oil horizons in the Mississippian series, should be absent over much or all of the quadrangle. The McClosky and probably the Tracey sands are, however, present. Whether or not there are valuable oil pools in these sands is believed to depend on whether there are small local domes in the generally flat-lying rocks which underlie all but the southwestern corner of the quadrangle. The presence or absence of such domes can not be predicted in advance because the slight irregularities in the surface rocks are known to be independent of the structure of the deep rocks.

It is possible that small oil pools in the Tracey or McClosky sands will be discovered within the quadrangle, but prospecting must be blind, and it is doubtful whether any pools that may be found will repay the cost of prospecting.

OIL AND GAS IN THE VINCENNES QUADRANGLE

By John L. Rich

(In cooperation with the U. S. Geological Survey)

OUTLINE

ILLUSTRATIONS

INTRODUCTION

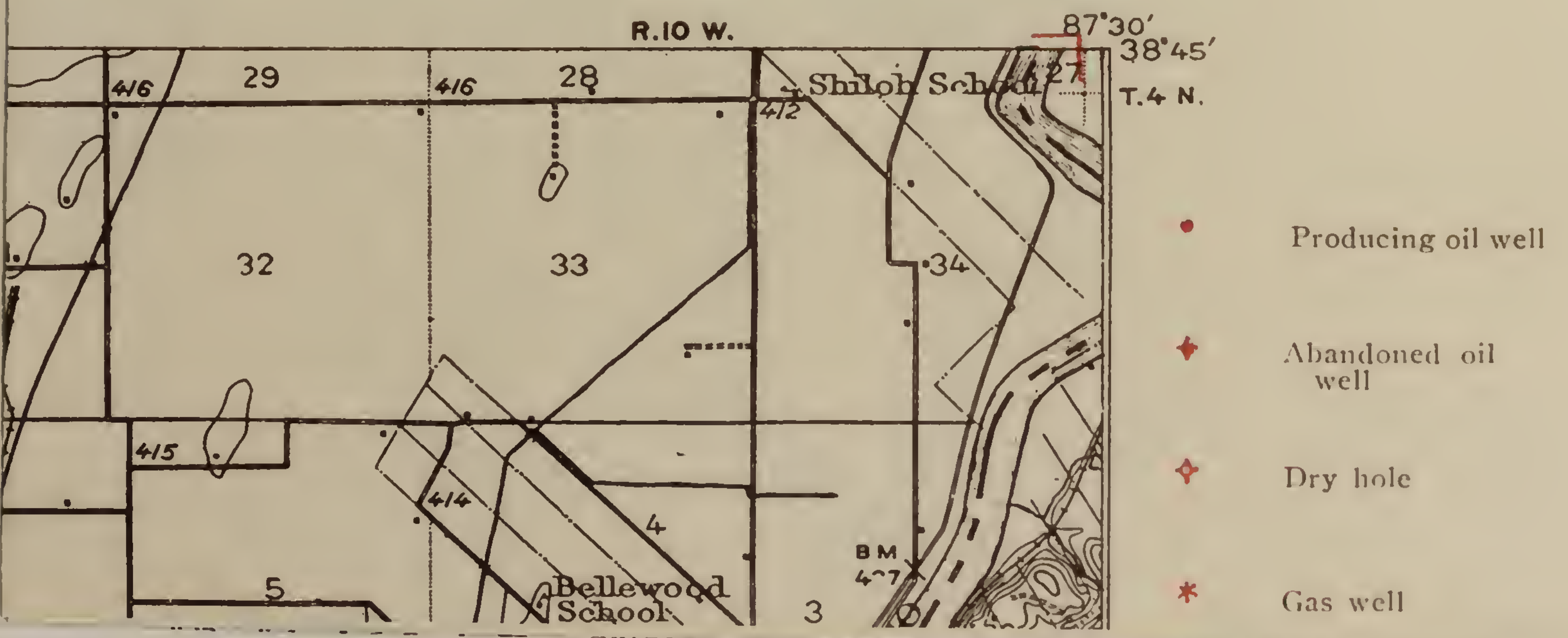
Scope of Report

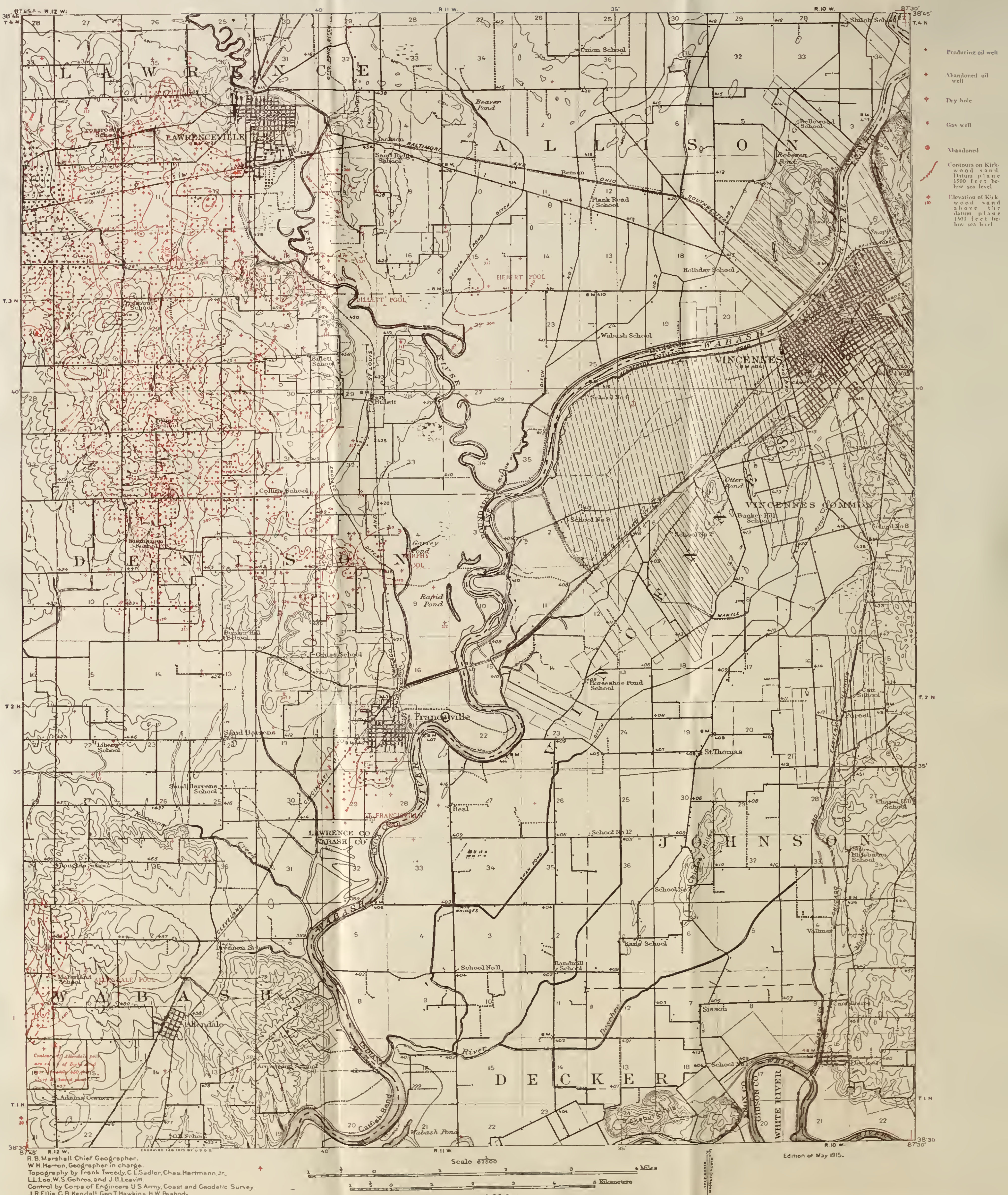
About one-half of the deep oil field of southeastern Illinois lies within the Vincennes quadrangle. This field was described in detail by R. S. Blatchley in 1913 and the oil development to July 1, 1911, was shown on the map accompanying his report.[1] Since the completion of the field work on which Blatchley's report was based, there has been a considerable extension of the oil pools within the quadrangle and four important, though small, new pools have been opened. The purpose of this report is primarily to present the results of an investigation of these new pools and of the development within the older fields since July 1, 1911. The general geological conditions of the area and the oil-bearing formations within the older field will receive only brief description, since they have been thoroughly covered in the report already mentioned. The emphasis will be placed upon the new developments since 1911.

Field Work

The wells in the new fields were located and their elevations determined in September, 1915, by a party under the charge of Mr. W. S. Nelson of the State Geological Survey. The plane table and telescopic alidade were used. The locations and elevations of scattered dry holes

[1]Blatchley, R. S., Oil fields of Crawford and Lawrence counties: Ill. State Geol. Survey Bull. 22, 1913.


R.10 W.
87°30′
38°45′
T.4 N.
Shiloh School
Bellewood School
29
28
32
33
34
4
5
3
416
416
412
415
414
B M
Producing oil well
Abandoned oil well
Dry hole
Gas well



Map showing oil fields of the Vincennes quadrangle

and of the wells within the main oil field were determined by pacing and hand level. The work was done by W. S. Nelson, E. F. Rehnquist, Mason K. Read, and the writer. All of the scattered dry holes and many of the wells within the producing area were thus definitely located, but time did not permit the location of all the latter. The remainder have been located from the map of the Ohio Oil Company. Their elevations were determined approximately by reference to the United States Geological Survey topographic map of the region.

Acknowledgments

Grateful acknowledgment is made to one and all of the oil companies and independent operators in the field who have furnished records and other data indispensable for the preparation of the report. To Mr. W. S. Nelson and to the other members of the surveying party, grateful acknowledgment is also made. The writer has incorporated the substance and part of the actual wording of an unpublished manuscript on the oil and gas resources of the Sumner and Vincennes quadrangles prepared by Mr. R. S. Blatchley for use in a United States Geological Survey folio now in preparation. The map herewith presented (Plate VIII) is a composite. It represents largely the work of Mr. Blatchley, who in 1913 prepared a similar map for insertion in the United States Geological Survey folio. To Mr. Blatchley's map the new data were added and whatever changes were necessary as a result of the additional information were made by the writer. The contouring, except in the new pools, is essentially the work of Mr. Blatchley. The writer has modified his contours only with respect to the newer data.

PHYSIOGRAPHY

The physical configuration of the Vincennes quadrangle is dominated by the plains, terraces, and bluffs of Wabash River which crosses the quadrangle from northeast to southwest, and by those of Embarrass River which enters near the northwest corner and joins the Wabash a little north of the center of the sheet. Flood plains and terraces of these two streams, together with accordant plains along Raccoon Creek and other tributaries, cover nearly three-fourths of the quadrangle. The remaining fourth is occupied by low, rolling hills whose relief ranges between 50 and 100 feet. The greater part of the oil field is situated on the hills south of Lawrenceville. The Allendale field, also is on the group of low hills west of that town.

The physical features of the quadrangle are, on the whole, favorable for the operations connected with the development of its oil resources. The fact that the greater part of the field lies in the hilly parts of the quadrangle greatly facilitates the transportation of the oil, since the topography permits a gravity system to be operated. At the same time

the topography is not sufficiently rough to interfere seriously with pumping the wells or with the hauling of supplies.

GEOLOGY

General Statement

The geological formations at the surface and in the wells of the Vincennes quadrangle belong to the Mississippian and the Pennsylvanian series of the Paleozoic group and to the Quaternary and Recent groups. The latter groups include glacial drift, alluvium, and wind-blown sand which mantle the bed rocks of the region.

Mississippian Series

The Mississippian rocks are the oldest and deepest of those here described. In this part of the State three formations are recognized: the St. Louis at the base, the Ste. Genevieve, and strata of the Chester group at the top. The Ste. Genevieve and the Chester contain important oil horizons—the former, the McClosky; the latter the Tracey and the Kirkwood sands.

ST. LOUIS FORMATION

The St. Louis limestone is the rock penetrated by the deepest wells in the quadrangle. It is a hard, light-blue to yellowish limestone in part dolomitic and containing some chert. A well recently drilled on the Collison farm (Collison well No. 2), sec. 27, T. 2 N., R. 12 W. (Denison Township), a log of which is published herewith, penetrated the St. Louis formation to a depth of over 250 feet. The formation consisted of lime throughout, some of it dolomitic and some cherty, but mainly pure limestone. The rock as a whole was very hard, but occasional softer beds were encountered. The latter showed oil at several horizons but in very small quantities. Other wells within the quadrangle have penetrated as as much as 890 feet of St. Louis limestone.[2] Nowhere has the formation been found productive of oil in paying quantities.

[2]Blatchley, R. S., Oil fields of Crawford and Lawrence Counties: Ill. State Geol. Survey Bull. 22, p. 85, 1913.

Log† of Collison well No. 2, NW. ¼ NE. ¼ sec. 27, T. 2 N. R. 12 W.

(Elevation 443 feet)

Description of strata	Thickness *Feet*	Depth *Feet*
Quicksand	99	99
Sand (water)	26	125
"Slate"	185	310
Lime	15	325
Red rock	10	335
"Slate"	115	450

Description of strata	Thickness Feet	Depth Feet
Coal	5	455
"Slate"	45	500
Lime	15	515
Sand (water)	10	525
"Slate"	15	540
Lime	5	545
Coal	8	553
Lime	7	560
"Slate"	5	565
Lime	95	660
Sand	10	670
Lime	8	678
"Slate"	112	790
Lime	5	795
"Slate"	25	820
Lime	8	828
"Slate"	22	850
Lime	50	900
"Slate" (broken)	125	1025
Lime	20	1045
Lime (broken)	20	1065
"Slate," black	20	1085
Sand (water)	15	1100
Lime	10	1110
"Slate"	65	1175
Lime	10	1185
"Slate"	5	1190
Sand (water)	50	1240
"Slate"	5	1245
Lime	31	1276
"Slate"	12	1288
Lime	22	1310
"Slate"	10	1320
Lime	20	1340
"Slate"	26	1366
Lime	10	1376
Lime, sandy	30	1406
Sand (show of oil)	10	1416
Sand (broken)	10	1426
Sand and shells (water)	49	1475
Shale	25	1500
"Slate"	20	1520
Limestone (broken)	70	1590
?	10	1600
Lime, very hard	15	1615
Sand	15	1630
Lime, gritty	30	1660
Sand (water)	50	1710
"Slate"	10	1720

Description of strata	Thickness Feet	Depth Feet
Lime	23	1743
"Slate"	47	1790
Lime	10	1800
Broken	30	1830
Red rock	12	1842
Lime, very sandy	19	1861
Sand (and wash of oil)	4	1865
Sand (water)	25	1890
"Slate"	2	1892
Lime	3	1895
"Slate"	20	1915
Lime	25	1940
"Slate"	15	1955
Shale, green	15	1970
Red rock	2	1972
Sand, brown (show of black oil)	10	1982
"Slate," black	17	1999
Lime, brown (streaks of red shale)	66	2065
Lime, brown	54	2119
Lime, brown, small oolites (green oil)	5	2124
Lime, blue, hard	8	2132
Lime, brown (water, little black oil)	2	2134
Lime, brown, hard	9	2143
Lime, brown, soft (show of green oil)	2	2145
Lime, brown, hard	10	2155
Lime, brown, soft (show of oil)	5	2160
Lime, brown, very hard	9	2169
Lime, soft (little show of oil)	2	2171
Lime, brown (wash of oil now and then)	57	2228
Lime, brown (showed oil)	2	2230
Lime, brown, hard	15	2245
Limestone, gray, white, coarse	10	2255
Lime, brown (show of oil)	15	2270
Lime, brown (show of oil)	20	2290
Lime, light brown	10	2300
?	7	2307
Dolomite, light brown; quartz fragments	43	2350
Lime, light brown, pure	5	2355
Lime, a little chert, light brown	10	2365
Lime, dolomitic, light brown	10	2375
Lime, dolomitic, light brown; some chert	15	2390
?	29	2419
Limestone, dolomitic	6	2425

Continued in limestone to a little over 2,500 feet; at bottom struck 2½ feet of "Blue Lick" water.

†The base of the Pennsylvanian series is believed to be at either 1,240 or 1,475 feet. The sand, with a showing of oil, at 1,406 to 1,416 feet, correlates with the Biehl sand of the Allendale field. The sand at 1,861 feet is believed to be the Kirkwood and that at 2,119 the McClosky. The top of the "big lime" is at some point between 2,000 and 2,065.

Log of Jane Jones well No. 7, N.W. ¼ N.W. ¼ sec. 28, T. 2 N., R. 11 W.*
(Elevation 409 feet)

Description of strata	Thickness *Feet*	Depth *Feet*
Soil	8	8
Sand and gravel	16	24
Sand	71	95
"Slate" and shells	115	210
Lime	3	213
"Slate"	4	217
Lime	11	228
"Slate"	12	240
"Slate"	90	330
Lime	6	336
"Slate"	49	385
Sand	30	415
"Slate"	85	500
Lime	6	506
"Slate"	225	731
Lime	6	737
"Slate"	13	750
Lime	6	756
"Slate"	30	786
"Slate"	6	792
"Slate"	10	802
Sand	10	812
"Slate"	70	882
Lime	6	888
"Slate"	22	910
Gritty lime	10	920
"Slate"	30	950
Lime	5	955
"Slate"	30	985
"Slate"	5	990
Lime (gritty)	10	1000
"Slate"	3	1003
Lime	12	1015
Sand (broken)	15	1030
Sand	75	1105
"Slate"	20	1125
Lime	25	1150
"Slate"	25	1175
Lime (gritty)	25	1200
"Slate"	25	1225
Lime	5	1230
"Slate"	10	1240
Sand (broken)	60	1300
"Slate"	30	1330
Sand	20	1350
"Slate"	21	1371
Lime (gritty)	29	1400

Description of strata	Thickness Feet	Depth Feet
"Slate"	6	1406
Lime (gritty)	19	1425
"Slate"	20	1445
Sand (water at 1450)	70	1515
Lime	17	1532
"Slate"	59	1591
Lime (gritty)	5	1596
Sand	20	1616
Lime (gritty)	9	1625
"Slate"	50	1675
Lime	15	1690
"Slate"	10	1700
"Slate," red	2	1702
Lime	13	1715
"Slate"	15	1730
Lime (gritty)	10	1740
"Slate"	10	1750
Lime	10	1760
Sand	10	1770
"Slate"	8	1778
Lime	2	1780
"Slate"	10	1790
Lime (gritty)	60	1850
Lime changing from light to dark brown and black from 1850 to 2565; "Blue lick" water at 2540 to 2560; little water at 1900; small show of oil at 2150.		

*The base of the Pennsylvanian series is at 1,515 feet; the horizon of the St. Francisville oil is between 1,790 and 1,850 feet.

Log‡ of Nellie Tracy hole No. 2, NE. ¼ NE. ¼ sec. 13, T. 3 N., R. 12 W.

(Elevation approximately 425)

Description of strata	Thickness Feet	Depth Feet
Lime shell	170	170
Sand	70	240
Lime	15	255
"Slate"	7	262
Big lime shell	12	274
Red rock	10	284
Lime	6	290
"Slate"	10	300
"Slate"	200	500
Lime	40	540
"Slate"	35	575
Lime	28	603
Sand	23	626
"Slate"	19	645
Salt sand (water)	30	675
"Slate"	10	685
"Slate," white	10	695
Sand	48	743

Description of strata	Thickness Feet	Depth Feet
"Slate"	192	935
Sand	15	950
"Slate"	15	965
Bridgeport sand (water at 985)	85	1050
"Slate"	20	1070
Sand	88	1158
"Slate"	12	1170
Lime	10	1180
"Slate"	5	1185
Lime	13	1198
"Slate"	20	1218
Lime	14	1232
"Slate"	75	1307
Lime	21	1328
"Slate"	24	1352
Buchanan sand	23	1375
"Slate"	11	1386
Lime	9	1395
"Slate"	5	1400
Lime	65	1465
"Slate"	4	1469
Lime	3	1472
"Slate"	3	1475
Red rock	10	1485
"Slate"	20	1505
Lime	20	1525
"Slate"	16	1541
Kirkwood sand	6	1547
"Slate"	5	1552
Sand	50	1602
Top of pay, 1573		
Bottom of pay, 1595		
"Slate"	78	1680
Lime	6	1686
"Slate"	3	1689
Sand, show of oil (Tracey)	12	1701
"Slate"	3	1704
Red rock	4	1708
Lime	5	1713
"Slate"	4	1717
Red rock	11	1728
"Slate"	10	1738
Lime	20	1758
"Slate"	3	1761
Lime	19	1780
McClosky sand	4	1784
Lime	53	1837
McClosky sand (lower)	2	1839
Lime	116	1955

‡The base of the Pennsylvanian series, and top of the Mississippian (Chester) is at 1,375 feet; the top of the "Big Lime" (Ste. Genevieve) is at 1,761 feet.

STE. GENEVIEVE FORMATION

The Ste. Genevieve limestone, about 85 feet thick, overlies the St. Louis formation from which it is not easily distinguishable in well records. It is, however, softer than the St. Louis and is characterized by oolitic beds. The Ste. Genevieve limestone is one of the most important oil horizons in the State in being the source of the McClosky oil. The oil is found commonly 20 to 50 feet below the top of the formation, though in places it is considerably lower, probably in distinct lower beds.

The Ste. Genevieve limestone appears to be very evenly bedded in strong contrast to the overlying formations which are characteristically irregular. This feature is clearly brought out on the profile (Pl. X, A) of the Murphy oil pool which presents a graphic comparison of the McClosky oil horizon in the Ste. Genevieve formation with the Kirkwood, Buchanan, and Bridgeport horizons.

CHESTER GROUP

The Chester group lies unconformably on the Ste. Genevieve in such a way that only the upper part is present in this area. The Chester rocks consist of relatively thin-bedded limestone, shale, sandstone, and near the base thin layers of "red rock" (red shale). Limestone and shale predominate. The average thickness of the formation in this region is 365 feet with a range of 295 to 440 feet.[3] According to the writer's correlation, the maximum thickness in the Allendale field is about 550 feet. The top of the formation is uneven. It is thought to represent the low hills and shallow valleys on an old buried land surface. Two or more thin beds of red shale are prominent features of the formation. They commonly lie both above and below the Kirkwood sand.

The Chester group contains two important oil-producing horizons, the Kirkwood and the Tracey sands. The former averages about 200 feet; and the latter, near the base, a little over 300 feet below the top of the formation. South of the main oil field, in the St. Francisville and Allendale pools, the intervals are 50 to 200 feet greater.

Pennsylvanian Series

The Pennsylvanian series in southeastern Illinois is represented by three formations: the Pottsville at the base, the Carbondale, and the McLeansboro. The latter constitutes the bed rock at the surface over the entire quadrangle. The lower formations are known only from well records.

POTTSVILLE FORMATION

The Pottsville formation consists mainly of sandstone and shale, with a few thin beds of limestone. The formation is 300 to 600 feet thick,

[3] Idem, p. 83.

averaging about 450 feet. It is thinnest on the higher parts of the La Salle anticline and thicker toward the east in the less-disturbed area. Along the eastern side of the oil field its average thickness is about 500 feet.

The Pottsville formation is marked by two prominent sandstone horizons, the Buchanan sand at the base and the Bridgeport sand near the top. Both are very massive and range in thickness from 50 to over 150 feet, averaging at least 100 feet. Both vary greatly in thickness from place to place and are irregular at both top and bottom. The Buchanan sand is the basal sandstone of the formation and was spread out along the shores of the sea as it advanced over the Chester land surface. Over most of the quadrangle the Buchanan sand contains large quantities of salt water. Locally, however, on the higher parts of the structure oil is found at the top of the sand.

The Bridgeport sand corresponds to the Robinson sand of the Birds and Hardinville quadrangles. It also contains large quantities of salt water over most of the area, though near the southern end of the main oil field, an area of three to four square miles is productive of oil.

CARBONDALE FORMATION

The Carbondale formation, about 300 feet thick, overlies the Pottsville. It contains the important coal beds in this part of the State and consists mainly of shale with some sandstone, thin beds of limestone, and coal. The "shallow" sand which is productive of oil in a few wells at the extreme south end of the main oil field, probably lies near the top of this formation.

MCLEANSBORO FORMATION

The McLeansboro formation, as exposed at the surface and encountered in the wells, consists mainly of gray to black, micaceous shale and shaly sandstones, massive sandstones, and a few thin beds of limestone. It presents no features worthy of special mention except a remarkably persistent bed of red shale associated with thin limestones which lies approximately 150 to 200 feet above the base of the formation.

Quaternary and Recent Rocks

Glacial drift, alluvium, loess, and wind-blown sand constitute the rocks of Quaternary and Recent age within the quadrangle. The glacial drift was spread out as a mantle of varying thickness over the entire area at the time of the Illinoian glacial period. The drift consists mainly of till or bowlder clay, a compact mixture of fine clay with pebbles and bowlders. The glacial drift is encountered at all points within the quadrangle where it has not been removed by stream cutting. The common practice in drilling oil wells is to extend a conductor or drive pipe through

the drift and seat it upon the underlying bed rock. The length of drive pipe necessary varies from 10 to over 100 feet.

A large part of the quadrangle is occupied by the flood plains and terraces of Wabash and Embarrass rivers and by alluvial plains which have extended up the streams tributary to them during a period of general silting up of the rivers. The depth of alluvium, as revealed by the well records, varies commonly between 50 and 100 feet. Quicksand and gravel are the commonest constituents of the alluvium below the soil zone, which is a sandy loam. The quicksand sometimes causes considerable difficulty in starting drilling operations.

Loess, a fine, wind-blown dust, is spread out in a bed from 3 to 20 or more feet in thickness over the drift in all parts of the quadrangle not occupied by recent alluvium. Loess constitutes the soil of most of the western part of the quadrangle.

Wind-blown sand, derived apparently from the flood plains of Wabash and Embarrass rivers, covers considerable areas near Allendale and St. Francisville, a small area northeast of Billtee, and the bluff along the east side of the quadrangle south of Vincennes.

OIL AND GAS

Main Field

PRODUCTIVE OIL SANDS

Named in the order in which they are encountered by the driller, the productive oil horizons of the Vincennes quadrangle are the "shallow" sand, the Bridgeport, Buchanan, Kirkwood, Tracey, and McClosky sands. The position of each of these in the geological column has been indicated in preceding paragraphs. A brief description of each and of its development within the quadrangle is here presented. For a more detailed account the reader is referred to Blatchley's report in Bulletin 22 of the State Geological Survey.

MCCLOSKY SAND

"The McClosky sand has yielded the largest initial productions of any of the producing sands in Illinois".[4] This sand has yielded several gushers, notably in the Murphy pool, to be described in detail in a following section. The McClosky oil comes from a thin sandstone, or in places, apparently from a soft, oolitic limestone in the upper part of the Ste. Genevieve formation. The productive horizon is commonly thin, ranging from 2 to 10 feet in the Murphy pool and averaging not more than 10 feet over the entire field. It is clearly not a single bed everywhere. It is rather a zone in the upper part of the Ste. Genevieve formation, in which here one, there another, bed carries the oil, the porosity of

[4]Idem, page 113.

the rock being evidently the controlling factor. Within this zone, which has a maximum observed thickness of 80 feet, one to three oil-bearing horizons are reported. In nearby wells it is not uncommonly found that in one well the upper porous zone is productive; in another the lower.

Localities where two or three oil-bearing beds of the McClosky have been noted are in secs. 12 and 13, T. 3 N., R. 12 W. (Lawrence Township); secs. 23 and 24, T. 3 N., R. 12 W. (Dennison Township); and secs. 15, 22 and 23, T. 3 N., R. 11 W. (Allison Township). Pl. X, B, a section along the north line of sec. 13, T. 3 N., R. 12 W., illustrates this feature. In other places, notably in the Murphy pool, a single productive bed is dominant, though even here a tendency to multiplicity is apparent.

This multiple character of the McClosky oil horizon makes it impossible to represent accurately its structure by structure contours, and it makes inevitable a margin of error of approximately 80 feet in the correlation of scattered outside wells yielding data on the McClosky. Nevertheless, where a single bed can be identified over a considerable area the McClosky is found to be much more uniform than any of the higher oil sands. In other words, the Ste. Genevieve limestone is evenly bedded and differences in elevation in different localities represent the dip of the rocks, not, as in the case of some of the higher sands, merely irregularities in the thickness of the sand bed. The depth of the McClosky horizon below the surface of the ground varies with the surface topography and with the structure of the underlying rocks, from 1,700 to about 1,860 feet for the producing territory. These depths correspond to elevations of 70 to 260 feet above a datum plane 1,500 feet below sea level. This variation is due mainly to the dip of the rock, but partly to the compound nature of the McClosky horizon. Outside of the productive territory, in scattered dry wells off the anticline (Pl. VIII), the depth as a rule is greater.

Though many of the McClosky wells have shown enormous initial yields, a large number have declined rapidly, and many others have been small producers. Owing to the expense of drilling the deep wells, the latter have to some extent offset the gain from the more prolific wells.

The McClosky oil is green, with a large sulphur content, and its gas has a rank odor.

The McClosky sand is productive over a belt from one-half mile to two miles wide, extending north and south through the principal oil field and including large parts of secs. 14, 23, 25, 26, 35, and 36, T. 3 N., R. 12 W., and sec. 2, T. 2 N., R. 12 W., and in several small outliers in the same general area. Outside the main field a small pool has been located in the SW. cor. sec. 17 and the NW. cor. sec. 20, T. 3 N., R. 11 W. (Lawrence Township), and in secs. 15, 22, and 23, T. 3 N., W. 11 W., as well as in the prolific Murphy pool in secs. 5 and 8, T. 2 N., R. 11 W. (Dennison Township).

TRACEY SAND

The original Tracey sand developed by Busch and Everett on the Tracey and Seed farms, sec. 13, Lawrence Township, has on investigation proved to be McClosky. The term Tracey has, however, persisted and has been applied to a sand intermediate between the McClosky and the Kirkwood. The designation as now used applies to a soft, calcareous sandstone, in the lower part of the Chester group, which lies on the average from 100 to 118 feet above the upper productive horizon of the McClosky sand. The Tracey oil horizon, to an even more marked degree than the underlying McClosky is a zone in which sands are developed irregularly and discontinuously rather than a single bed of sand. The horizon is more irregular and the sandy phases are less continuous over the field than in any of the other oil-bearing horizons. The sand rarely attains a thickness of more than 50 feet. The Tracey commonly yields a "sour" or sulphur oil of high gravity. In the Vincennes quadrangle the production is mainly oil, gas being subordinate, but at the northern end of the field in the Hardinville quadrangle gas is the chief product.

Owing probably to the irregular development of sands at the Tracey horizon, the producing areas within the main field are confined mainly to small isolated pools, the only notable exception being a pool which covers about three square miles mainly in secs. 25, 26, 35, and 36, T. 3 N., R. 12 W., and the NE. ¼ sec. 2, T. 2 N., R. 12 W. The second largest pool lies in the SW. ¼ sec. 11, and the NW. ¼ sec. 14, and adjacent portions of secs. 10 and 15, T. 3 N., R. 12 W.; a third and smaller pool has been developed in the western part of sec. 23, T. 3 N., R. 12 W.; and there are several small isolated areas in which from one to ten wells are producing from this sand.

KIRKWOOD SAND

The Kirkwood is by far the most prolific oil horizon within the quadrangle. Not only does it cover a larger area than any of the others, but it shows excellent initial production and is long-lived and steady in its yield. Furthermore, its depth is not excessive, ranging in the main field from about 1,400 feet to about 1,590. In the St. Francisville pool it is 1,830 to 1,850 feet below the surface, and in the Allendale pool it is presumed to lie still deeper. The Kirkwood horizon lies about 100 feet on the average, varying somewhat between 90 and 130 feet, above the top of the Tracey sand. Since the McClosky is more regular in its bedding than the Tracey a more definite expression of the position of the Kirkwood is given by the statement that it lies on the average 200 to 230 feet above the upper lens of the McClosky.

In several localities within the quadrangle the Kirkwood sand is lenticular, having in many places two and even three lenses. In some places the lower, in others the upper, beds are developed. The thickness of the

sand also varies greatly, ranging from 0 to 100 feet. The average thickness has been computed by Blatchley to be 33 feet. Owing to irregular thickening and thinning both the top and the bottom of the sand bed or beds are irregular. On account of this irregularity and of the replacing of one lens here and there by another higher or lower in the series, contours drawn on the top of the Kirkwood sand show many irregularities which should not be interpreted as structural features of the rock formations as a whole. The contours do, however, represent with the greatest attainable accuracy the elevation at the various localities of the upper sand of the Kirkwood horizon.

A conception of the general structure of the oil field may best be gained from the contours on the Kirkwood sand by omitting in imagination all of the minor irregularities of the contours and considering only their broader features.

The Kirkwood sand, in spite of its uneven thickness and lenticular character, is remarkably persistent.

"The Kirkwood sand is a medium, fine-grained sand often called the 'sugar' sand because it resembles brown sugar in the churn-drill samples. * * * * * The * * * oil is generally considered sweet oil which is more free from sulphur than is the oil from the lower sand, although in some localities the sulphur content is variable. The average specific gravity of the oil is about 36° Beaumé".[5] Some gas is produced with the oil over a large part of the field.

In the main oil field the outlines of the territory in which the Kirkwood is productive nearly coincide with the outlines of the field itself. A notable exception occurs in secs. 15, 16, and 21, T. 3 N., R. 12 W., and secs. 27, 34, and 35, T. 3 N., R. 12 W., and sec. 3, T. 2 N., R. 12 W., where the Buchanan and Bridgeport sands are productive beyond the Kirkwood limits. Outside the main field productive pools in the Kirkwood have been opened in secs. 1 and 12, T. 3 N., R. 12 W. (Lawrence Township); in the Billett pool secs. 13, 17, and 18 (Lawrence Township); at the eastern end of the Murphy pool secs. 4 and 5, T. 2 N., R. 11 W.; and in the St. Francisville pool, secs. 20, 28, and 29, T. 2 N., R. 11 W. (Dennison Township). Each of these outside pools will be described in detail in following sections.

BUCHANAN SAND

The Buchanan sand which constitutes the basal sandstone of the Pottsville formation is persistently developed over the entire quadrangle. As already indicated, it averages about 100 feet thick and in the main field its top lies on the average about 250 feet above the top of the Kirkwood sand, but the interval is much greater off the anticline at St. Francisville (440±) and at the Allendale pool (460±). Almost everywhere

[5]Blatchley, R. S., Unpublished manuscript of Vincennes-Sumner folio.

in the quadrangle the sand is filled with salt water, and it is only at a few localities, notably secs. 15, 16, and 21, T. 3 N., R. 12 W., on the western border of the quadrangle; a small area north of Lawrenceville; another at the southern end of the field; and in the Allendale pool, that it is productive of oil. Inasmuch as there has been no significant development or extension of the territory producing from this sand, except in the Allendale pool, which has already been fully described,[6] the reader is referred to Blatchley's original description and to the Allendale report for more detailed accounts.[7]

BRIDGEPORT SAND

The Bridgeport sand, like the Buchanan, is widely developed within the quadrangle, but almost everywhere contains only salt water. A notable exception is an area of a little over 3 square miles at the southern end of the main oil field. This has been fully described in Blatchley's report, and inasmuch as there have been no developments of moment since that report was written, it is not here described in detail.

"SHALLOW" SAND

The oil pools in the shallow sand are limited to the extreme south end of the main oil field. There are but 8 producing wells in this sand, and these yield a very small amount of oil. The average depth of the sand is about 450 feet, being about 500 feet above the Bridgeport sand.[8]

RECENT DEVELOPMENTS IN THE MAIN FIELD

GENERAL STATEMENT

The recent developments have been mainly the routine drilling of leases already outlined and proved at an earlier date. This inside drilling has resulted in increasing here and there the areas of the productive pools in the various sands, particularly in the deeper sands, and in the closer delineation of the limits of these pools. The outlines of the oil pools in the various sands as developed on September 1, 1915, are shown on Plate IX. A comparison of this map with those published in Bulletin 22 will indicate the increase in productive territory and the new discoveries since July 1, 1911, the date at which the field work for Bulletin 22 was completed.

In a belief that it may have value in indicating the trend of recent developments within the field, the most important additions to the productive territory of each of the sands made within the last two years are outlined in order.

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[6]Kay, Fred H., and others, Oil investigations in Illinois in 1914: Ill. State Geol. Survey Bull. 31, pp. 59-68, 1915.

[7]Blatchley, R. S., Oil in Crawford and Lawrence counties: Ill. State Geol. Survey Bull. 22, 1913.

[8]Blatchley, R. S., Unpublished manuscript of the Sumner-Vincennes folio.

McCLOSKY SAND

Within the main field recent drilling has resulted in the following addition to the areas producing from the McClosky horizon. In the NW. ¼ sec. 12, T. 3 N., R. 12 W. (Lawrence Township), a small pool of 4 wells has been added, and near the center of the section two other new wells have been brought in. In the SW. ¼ sec. 24, T. 3 N., R. 12 W. (Dennison Township), a small pool one-half mile east of the main pool has been found. In the NW. ¼ sec. 35, T. 3 N., R. 12 W. (Dennison Township), the western limits of the large pool in this locality have been pushed westward about one-quarter mile. A similar extension has been made along the east side of sec. 27, T. 3 N., R. 12 W. In the western half of sec. 26, the completion of drilling has proved the McClosky to be productive.

TRACEY SAND

The only important additions to the productive area of Tracey sand have been made in secs. 23, 26, and 35, T. 3 N., R. 12 W., and sec. 2, T. 2 N., R. 12 W. The small pool along the south side of sec. 15, T. 3 N., R. 12 W., has been extended southward to include 3 new wells.

KIRKWOOD SAND

Within the main field the most important extensions of the Kirkwood area have been made in secs. 3 and 10, T. 3 N., R. 12 W. (Lawrence Township). Here about one-half square mile has been added to the productive field. A considerable addition has also been made in the somewhat isolated pool in the NE. ¼ sec. 12 and SW. ¼ sec. 1, T. 3 N., R. 12 W. (Lawrence Township). Considerable additional inside drilling was done and some extensions were made to the southeastern end of the pool in sec. 21, T. 2 N., R. 12 W., and secs. 6 and 7, T. 2 N., R. 11 W. (Dennison Township). The latter territory lies immediately west of the Murphy pool and serves to connect it with the main field.

BUCHANAN SAND

The only significant additions to the area of productive territory in the Buchanan sand were made near the center of sec. 11, T. 2 N., R. 12 W., where twelve new wells have been drilled without apparently exhausting the possibilities of further extension, and in the Allendale field.

BRIDGEPORT SAND

No significant additions to the territory producing from this sand have been made. A number of wells within the territory already outlined have been drilled and a few scattered ones outside, but these have resulted in no definite extension of the limits of the field.

"SHALLOW" SAND

In sec. 2, T. 2 N., R. 12 W. (Dennison Township), fewer than a half dozen new wells in the "shallow" sand have been drilled. They have not materially altered the limits of the area.

Oil Pools Developed outside the Main Field

GENERAL STATEMENT

Since the completion of the field work on which Mr. Blatchley's report was based, five small though important oil pools have been discovered outside the limits of the main field. These are, in order of their discovery: the Allendale, Billett, Hebert, Murphy, and St. Francisville pools. Of these the Allendale is in the Buchanan sand; the Billett is mainly in the Kirkwood sand; the Murphy and the Hebert mainly in the McClosky sand; and the St. Francisville is believed to derive its oil from the Kirkwood sand. Since the discovery of these outlying pools indicates the possibility of further extension of the field, each of them is here described in considerable detail.

ALLENDALE POOL

The Allendale pool is in the southwestern corner of the quadrangle about two miles northwest of Allendale. The western part of the field lies outside the limits of our map in the Sumner quadrangle. The larger part, however, lies within the area under discussion.

The field was studied by the writer in the summer of 1914, and in 1915 a detailed report was published by the State Geological Survey.[9] Since that study and report were completed an important addition to the field has been made at the northeastern end, and the completion of the Collison well about halfway between this field and the main pool to the north has made possible a revision of the correlation of the sands of the Allendale field. In that report the Biehl sand was correlated with the Kirkwood. The recent study has shown that it should, rather, be correlated with the Buchanan sand of the main field, though there is a possibility that it is a hitherto undiscovered sand in the upper part of the Chester group.

For a detailed description and map of the Allendale field as it existed in 1914, the reader is referred to the report already mentioned. A brief summary of the essential features of that report is here presented, together with a more detailed discussion of the recent development of the field.

The pool was opened in August, 1912, by a 650-barrel well on the Adam Biehl farm in the NE. cor. SE. ¼ sec. 4. A boom resulted and the field was rapidly developed and the surrounding territory tested.

[9] Rich, John L., The Allendale oil field: Ill. State Geol. Survey, Bull. 31, pp. 59-68, 1915.

The principal producing sand of the Allendale pool is known locally as the Biehl sand. A second sand lens, about 35 feet below the Biehl, which has been developed in the course of the recent drilling, is known as the Jordan sand. Over most of the field the Biehl sand is a single bed 20 to 30 feet in thickness, having a maximum observed thickness of about 45 feet. A marked local thinning of the sand was disclosed in the wells in the NW. ¼ sec. 9, and, in several wells south and east of the Biehl well, the Biehl sand is absent, and only the Jordan sand is encountered. This absence of the Biehl sand in the Lucy Courter well No. 1 and the Eli Jordan well No. 1 near the west center of section 3 led to an erroneous representation of the structure in the earlier report because the Jordan sand in these wells was taken for the Biehl which was supposed to have dipped down to the lower level actually occupied by the Jordan sand.

In the summer of 1915 the drilling of two productive wells in the northeastern part of the Allendale pool, one of them indicating the possible extension of the pool to the east, attracted renewed attention to the region. These wells were No. 8 on the Jacob Smith farm, two locations south of the Biehl well and the Jordan Brothers line well, one location east of Smith No. 8. Both wells produced from the Jordan sand at a horizon about 35 feet below the level of the Biehl sand. In both, the Biehl sand was lacking. Later in the year well No. 2 on the Eli Jordan farm and No. 2 on the Jo Jordan farm both proved productive and extended the limits of the pool one location farther east. The northern of these wells, Eli Jordan No. 2, had an initial production of 180 barrels. Both the Biehl and Jordan sands were encountered in each of the wells. On November 23, 1915, a 10-barrel well on the V. H. Price farm in the NE. ¼ NE. ¼ sec. 4 was completed. This proved that the field extends northward. The low yield of the well is probably attributable to lack of porosity in the sand, since structurally the Biehl sand is high, its top lying 511 feet above datum. On March 12, 1916, the complétion of a 300-barrel well on the Lucy Courter farm in the SW. ¼ NW. ¼ sec. 3, proved the pool to extend northeastward and created considerable excitement. During the spring and summer of 1916 drilling was in active progress. A letter from the field dated June 12th states that 5 wells have been completed on the Courter and Eli Jordan farms in the west half of sec. 3, and that two test wells in the SW. ¼ NE. ¼ sec. 3 and the SE. cor. SW. ¼ sec. 34, respectively, have proved dry. In the latter well the Jordan sand seems to lie about 40 feet lower than in the wells on the highest part of the Allendale dome. The principal production in the new wells is from the Biehl sand. In the Courter well No. 1 (Allendale Oil Company) the top of this sand is 512 feet above datum.

A restudy of the logs of the deep wells around the Allendale field in the light of the data from the Collison well leads to the conclusion that the

Biehl sand is not Kirkwood, but is a higher sand at least 450 feet above the Kirkwood, probably Buchanan.

It is certain, therefore, that the principal productive sands of the main oil field, the Kirkwood, Tracey, and McClosky, lie below the level of the Biehl sand. No wells on the higher parts of the Allendale dome have been drilled deep enough to test these sands. The deep wells south of the pool did not penetrate below the Kirkwood, and it is doubtful if more than one of them even reached it.

In the light of these facts it is believed that the deeper sands should be tested by one or more deep wells on the higher parts of the dome. The data at hand indicate that the Kirkwood sand should be struck about 450 to 475 feet, the Tracey 575 feet, and the McClosky 700 to 750 feet below the top of the Biehl sand. The anticlinal structure of the rocks in the Allendale field is favorable for the accumulation of oil in these lower sands. Should a deep well be drilled, samples should be saved systematically and sent to the State Geological Survey, charges collect, for examination.

The success of wildcat drilling east and northeast of the Allendale pool would seem to depend upon the accidental discovery of other small domes similar to that which is responsible for the Allendale pool. There is no direct indication that such domes are present.

BILLETT POOL

The Billett pool is 2 miles south of Lawrenceville. As developed in September, 1915, it covered an area of about one square mile in secs. 13, 17, and 18, Lawrence Township, and secs. 19 and 20, Dennison Township (T. 3 N., Rs. 11 and 12 W.). The pool is isolated, being separated on all sides from other productive territory by at least one-half mile of barren or untested ground. The first successful well in this area was drilled on the Roy Tracey farm in the NW. ¼ sec. 18, and the field was developed rapidly during the summer and autumn of 1913. The Tracey well encountered oil in the lower of two lenses of the Kirkwood sand 380 feet above datum. In the summer of 1915 very little development of the field was going on, but in the spring of 1916 several new wells were being drilled.

From the standpoint of the oil producer, the first important formation encountered in the wells in this region is the Bridgeport sand the top of which is here found at 930 to 1,000 feet above datum. This sand varies greatly in thickness, but not uncommonly is nearly 200 feet thick. In most of the wells it shows large quantities of salt water. Wells in the NW. ¼ section 18 struck a showing of oil at the top of the Bridgeport sand, but the quantity was not sufficient for exploitation. Below the Bridgeport sand are 120 to 280 feet of shale with some thin beds of limestone succeeded by the Buchanan sand 30 to 170 feet thick. The Buchanan is not

uncommonly broken into two or three lenses with limestone between. The elevation of the top of the Buchanan sand, as of the Bridgeport above it, varies within limits of nearly 100 feet on account of thickening and thinning and irregular development of the sand. The same is true of the bottom of both sands. Below the Buchanan is a series of limestones and shales with one or more thin beds of red rock. One of the latter is notably persistent at about 460 feet above datum, approximately 170 feet below the top of the Buchanan sand. Two hundred and fifty feet, on an average, below the top of the Buchanan sand is the Kirkwood sand. This is well developed and is encountered in almost every well, though it is notably lenticular, two and three lenses being as common as one, particularly in the western part of the field in the SE. ¼ sec. 13. At the eastern end of the pool only one lens, as a rule, is developed. The Kirkwood sand varies in thickness from 10 to 60 feet. From 20 to 25 feet is the most common thickness.

About 110 feet below the top of the Kirkwood is the Tracey sand. This is well developed at the western end of the field, though not found at the east. It is somewhat less lenticular than the Kirkwood. Its thickness averages about 20 feet, but varies in the wells from which it has been reported between 12 and 50 feet. Between the Kirkwood and the Tracey sands the rocks are prevailingly shale with a subordinate amount of limestone. Beneath the Tracey sand, revealed by the logs from this locality (see log of Nellie Tracey well No. 2 in early part of report), limestone constitutes at least 90 per cent of the rock.

About 200 feet below the Kirkwood, and a little less than 100 feet below the top of the Tracey, is the McClosky sand. This is not well developed at the western end of the field. Only one well obtains oil from it, and the amount is very small. At the eastern end of the field the McClosky sand has been struck in all the wells that have penetrated deep enough. It is only 2 to 10 feet thick. In one well three thin lenses were found within a vertical distance of 50 feet. The McClosky sand is notably more regular in its development than are any of the sands above. Beneath the McClosky sand wells have penetrated limestone to depths 100 to 200 feet below datum but have struck no more sand or oil.

The Billett pool is located on a low dome in rocks elsewhere lying approximately flat. The highest part of the dome is near its western end where the top of the Kirkwood sand reaches an elevation of 416 feet above datum. At the eastern end of the pool the rocks are 40 to 50 feet lower, but are higher than on either side.

A few wells are producing oil from the Kirkwood sand northeast of the Billett pool near the center of section 17, and in the NW. ¼ sec. 8, T. 3 N., R. 11 W. (Lawrence Township). The rocks are nearly flat at 340 to 360 feet above datum.

HEBERT POOL

The beginnings of the development of what may later prove to be a considerable pool in the McClosky sand were made in the summer of 1913 in secs. 14, 15, 22, and 23, T. 3 N., R. 11 W. (Allison Township). On September 1, 1915, seven wells were producing from the McClosky sand in this area. As is shown on the map, the wells are scattered in such a way as to indicate that an area of a square mile or more may be found productive. The yield, however, is small, from 12 to 40 barrels at the start. The oil is produced from flat-lying rocks at depths of 1,840 to 1,860 feet, or at elevations of 55 to 72 feet above datum. This is about 100 feet lower than the McClosky sand at the east end of the Billett pool 2½ miles to the west. The Kirkwood sand, however, at 320 to 335 feet above datum, is only 30 to 40 feet lower than at the east end of the Billett pool. It seems possible, therefore, that the McClosky oil in the area under discussion, may be produced from a lens somewhat lower than at the latter locality. This probability is heightened by the fact that in each of two of the wells two lenses of McClosky sand were encountered at 25 and 68 feet apart, respectively. The one produced oil from the lower lens, the other from the upper.

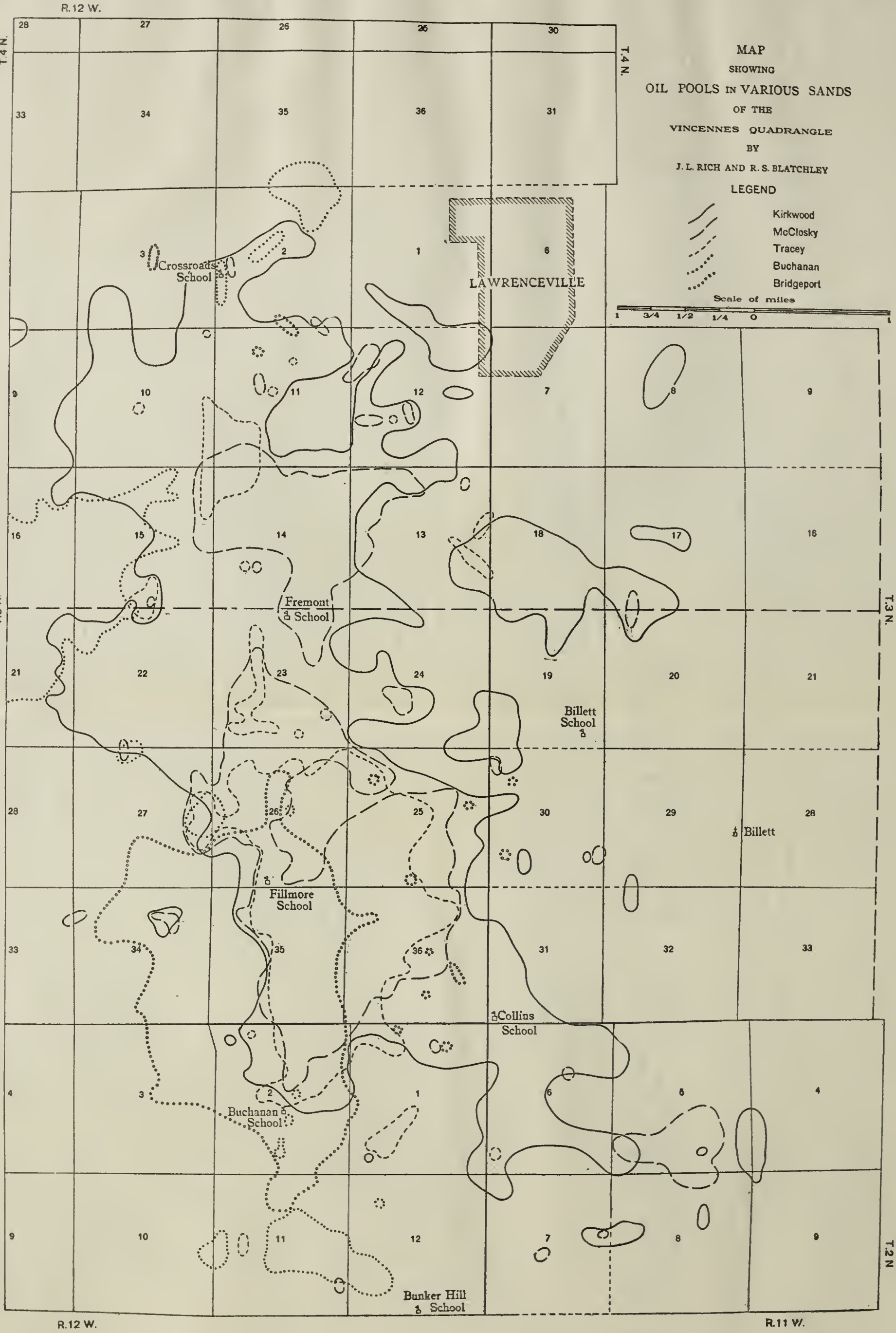
The data on the McClosky sand in the scattered dry wells in the neighborhood also indicate the probability that not all the McClosky records are on a single bed of sand.

MURPHY POOL

On April 6, 1914,[10] a 2400-barrel well on the M. J. Murphy farm, sec. 5, T. 2 N., R. 11 W. (Dennison Township), opened the Murphy pool. The original discovery was in the McClosky sand at a depth of 1,835 feet, and the greatest production has come from this sand though later drilling has revealed considerable productive territory in the Kirkwood sand. As developed in the summer of 1915, the pool, including both Kirkwood and McClosky sands, covered an area of about one-half square mile in the southern part of sec. 5, the southwestern part of sec. 4, and a small strip along the north side of sec. 8. The pool in the Kirkwood sand extends westward into the SE. ¼ sec. 6, T. 2 N., R. 11 W., whence it connects with a southeastern prolongation of the main oil field.

The McClosky sand in the productive pool is from 2 to 10 feet in thickness. It lies almost perfectly flat and about 100 feet above datum. The sand is very uniform, though in a few wells two lenses were noted, the upper of which carried gas. In most of the wells some gas was found with the oil. Outside the productive limits of the pool the McClosky sand either is absent or is broken into thin lenses some of which carry gas. The greatest production centered around a small area near the south center

[10] Kay, F. H., Petroleum in Illinois in 1914 and 1915, Ill. State Geol. Survey Bull. 33, 1916.


MAP
SHOWING
OIL POOLS IN VARIOUS SANDS
OF THE
VINCENNES QUADRANGLE
BY
J. L. RICH AND R. S. BLATCHLEY
LEGEND
Kirkwood
McClosky
Tracey
Buchanan
Bridgeport
Scale of miles
1 3/4 1/2 1/4 0 1
R.12 W.
R.11 W.
T.4 N.
T.3 N.
T.2 N.
LAWRENCEVILLE
Crossroads School
Fremont School
Billett School
Billett
Fillmore School
Collins School
Buchanan School
Bunker Hill School

of section 5. Here 6 wells produced the first day more than 1,000 barrels each, another 750 barrels. Outside this small area of great production the yield was relatively small, varying from 5 to 150 barrels. After the first few days the production declined very rapidly to such an extent that by September, 1914, the production of the entire pool is said to have been only 1,500 barrels per day—not much more than half the initial daily production of some of the best single wells.

The Kirkwood sand varies considerably in thickness, ranging from 10 to 95 feet. It averages about 30 feet thick. Within the productive area of the McClosky sand only one well reported oil from the Kirkwood though that sand was present in nearly every well. The outlines of the areas producing oil from the Kirkwood sand appear on the map (Pl. IX).

The production ranged up to 150 barrels for the first day. Water is reported in the bottom of the Kirkwood sand in several of the records. Over the area covered by the Murphy pool the Kirkwood sand seems to be a single continuous bed, though it varies greatly in thickness. There is considerable irregularity in its elevation, indicating that it was not deposited evenly. It is notably less regular than the McClosky sand below.

The Buchanan sand is present in a bed ranging up to 150 feet in thickness. In only one well was there any show of oil or gas. The Bridgeport sand with a thickness of somewhat over 100 feet, may also be recognized but is barren of oil or gas.

The McClosky sand, on account of its great regularity is the most favorable for a study of structure. Plotting of the elevations above datum, of this sand reveals the almost perfectly flat character of the beds. Within the producing area the range in elevation is from 90 to 110 feet. No systematic variation in elevation appears. Toward the west there may be a slight rise of the strata, but this can not be determined with certainty because of the poor development of the McClosky sand and the difficulty of exact correlations. The data on the Kirkwood sand, however, indicates a slight rise toward the west. In the SE. ¼ section 6 it stands 360 feet above datum as compared with about 330 feet along the east side of section 5 and the west side of section 4. Toward the east are no data on the McClosky sand, which appears to be absent; but the elevations of the Kirkwood indicate that there is no marked dip eastward from the productive portion of the Murphy pool, at least as far as has been explored.

ST. FRANCISVILLE POOL

In the early part of November, 1914, Taylor and others completed a successful test well on the Lagote farm about three-fourths of a mile southwest of St. Francisville. The well gave an initial production of 100 barrels. The ordinary local boom resulted, and within a year 44 wells had been drilled 35 of which were producing oil on September 1, 1915. In the spring of 1916, further extension of the field was in active progress. The

majority of the wells started with initial productions of 25 to 30 barrels per day.

The oil is encountered at a depth of 1,820 to 1,850 feet, or 60 to 85 feet above a datum plane 1,500 feet below sea level. It comes from a sand which varies in thickness from 4 or 5 to 60 feet. The oil is black instead of green like that from a similar depth in the Murphy pool. It lies 300 to 320 feet below the base of the Pottsville formation. This is approximately the position occupied by the Tracey sand in the field to the north, but the oil at St. Francisville is reported to be "sweet", whereas the Tracey oil is "sour". This characteristic, together with the absence of a well-defined sand corresponding to the Kirkwood above the producing sand, and the known thickening of the Chester rocks at the top in the Collison well and in the Allendale field, leads to the belief that the producing sand at St. Francisville should be correlated with the Kirkwood sand of the main field.

The relations which are known to apply in the Allendale field, and which seem also to apply here, between the rocks of the Chester group and those of the Pottsville are illustrated in the accompanying sketch (Fig. 14). This is not drawn strictly to scale and purposely exaggerates the

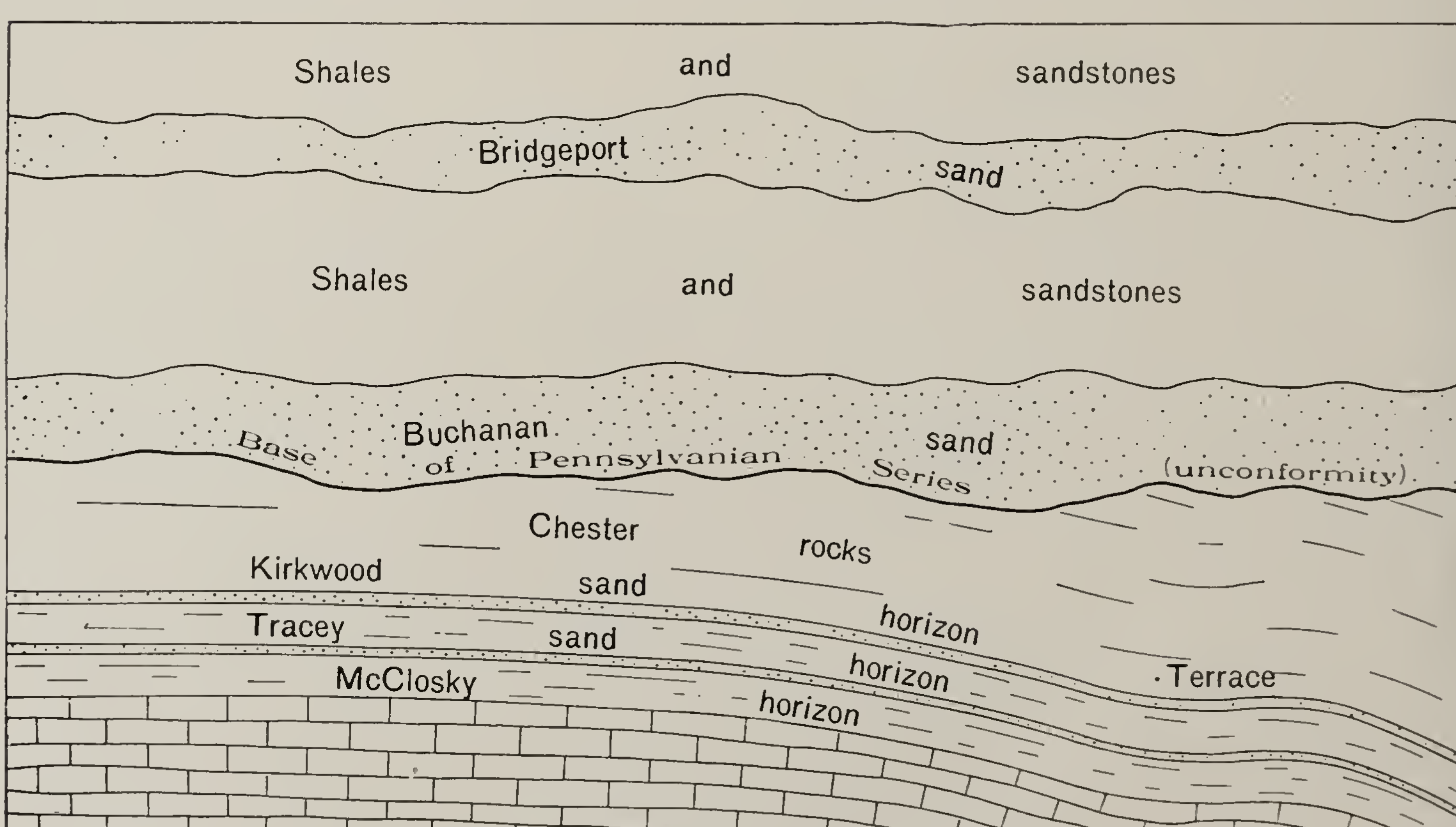


Fig. 14.—Diagrammatic illustration of the probable unconformable relation between the Mississippian rocks at the south end of the oil field.

vertical element, for the purpose of clearly expressing the idea of the unconformity between the rocks of the Mississippian and Pennsylvanian series, which at the southern end of the quadrangle, results in the lower level of the Kirkwood sand with respect to the sands of the Pennsylvanian rocks.

Both the higher sands, the Bridgeport and the Buchanan, contain large quantities of water. They lie in their regular position and are about 100 feet lower than in the Murphy pool.

Within the limits of the St. Francisville pool the producing oil sand lies nearly flat. It is also remarkably regular. There is a slight and uniform rise toward the east and southeast, the highest elevations of the sand being on the southeastern side of the field where it is 95 feet above datum. It appears probable that a further extension of the field will be made toward the southeast and possibly toward the east. The two dry wells on the eastern border of the pool owe their lack of oil to the absence of the sand bed. The records give no indication that the rocks there are lower. Should it happen, as it probable, that the absence of the sands is only local, there would be a good prospect that successful wells might be found farther east.

A well on the T. L. Lewis farm in the NW. ¼ NE. ¼ sec. 20, T. 2 N., R. 11 W., three-fourths of a mile north of the north end of the St. Francisville pool, struck the Kirkwood and McClosky sands at practically the same level as the wells in the Murphy pool. The rocks must, therefore, dip southward steeply from this well to the flat terrace on which the St. Francisville pool lies. Test wells in the surrounding territory do not yield records of sufficient detail to permit a more exact statement of the relation of the rocks of the St. Francisville field to those of other pools.

Structure of the Rocks in the Vincennes Quadrangle in Relation to the Accumulation of Oil and Gas

explanation of map

The principal features of the structure of the rocks in the portions of the quadrangle occupied by the main oil pool are shown on Plate VIII by structure contours on the top of the Kirkwood sand. In order that the contour numbers may be positive, all elevations are based on a datum plane 1,500 feet below sea level. The figures printed in connection with the contours and beside outlying wells represent elevations above this datum plane. Depth below sea level may be obtained by subtracting the figures given from 1,500, and depth below the surface of the ground by subtracting the contour figures from 1,500 plus the elevation above the sea of the mouth of the well.

For the outlying pools the contours on the top of the Kirkwood are shown where sufficient data could be secured. Elsewhere the elevations of the top of the Kirkwood above the datum plane are shown by printed figures beside the wells. In these outlying wells exact correlation of the formations is difficult on account of the horizontal variability in the character of the rocks and the incompleteness of most of the logs, the majority giving data only on certain sand beds. The figures given represent the

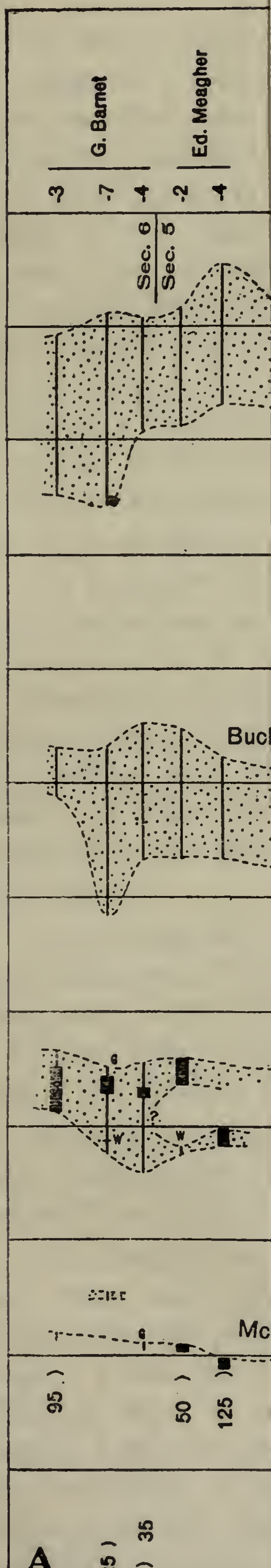
best correlations that could be made in the light of a comparative study of the logs. They are believed to be approximately correct.

STRUCTURAL FEATURES

As is clearly shown by the structure contours on the Kirkwood sand, the dominant structural feature of the quadrangle is the broad, low anticline, extending north and south through the area occupied by the main oil field a nearly flat terrace extending eastward from this anticline, and the low basin which occupies the southwestern portion of the quadrangle. The anticline is clearly marked along a line extending from sec. 2, T. 2 N., R. 12 W., northward for about 6 miles to sec. 1, T. 3 N., R. 12 W. (See west-east cross-section of anticline, Plate X, C.) At the north it appears to flatten out as the rocks dip northward toward the structural basin along Embarrass River. The anticline is connected along its northwestern side in secs. 15 and 16, 9 and 21, T. 3 N., R. 12 W., by a broad, nearly flat terrace with the sharper anticline which extends northward through the Sumner and Vincennes quadrangles from Bridgeport to Embarrass River. Along the western side of the anticline and terrace southward and southeastward, from the border of the quadrangle in sec. 21, T. 3 N., R. 12 W., the rocks on the western flank of the anticline dip deeply southwestward into the Illinois Basin. This steeply dipping flank of the anticline extends across the southern end of the oil field from sec. 10, T. 2 N., R. 12 W., toward St. Francisville, passing through the northern half of sec. 20, T. 2 N., R. 11 W., a short distance north of the town.

It is probable that a comparatively sharp monocline crosses the northeastern corner of the quadrangle in a northwest-southeast direction from the middle of the north line, northeast of which the rocks are 300 to 400 feet higher than on the southwest. The presence of this monocline is inferred from the logs of the deep wells in the Birds quadrangle to the north. The probability of the presence of this monocline is confirmed by the detailed log of a well on the Boonilletts farm, 4 miles north of Vincennes (not located on the map), in which the top of the Ste. Genevieve limestone is not less than 280 feet above datum.

The eastern flank of the principal anticline dips much less steeply than the western. From the crest is an eastward dip of about 40 feet in a distance of two miles beyond which the rocks flatten out, and the average dip, as is indicated by the records of the wells farthest east, does not exceed 10 feet per mile. On this flat eastern limb of the anticline small local domes 20 to 60 feet in height have permitted the accumulation of oil at several localities forming the Billett, Hebert, and Murphy pools. Throughout this area the general conditions for the accumulation of oil are moderately favorable wherever small local domes occur. Such domes are likely to be of small area, and their presence can be determined only by the drill.



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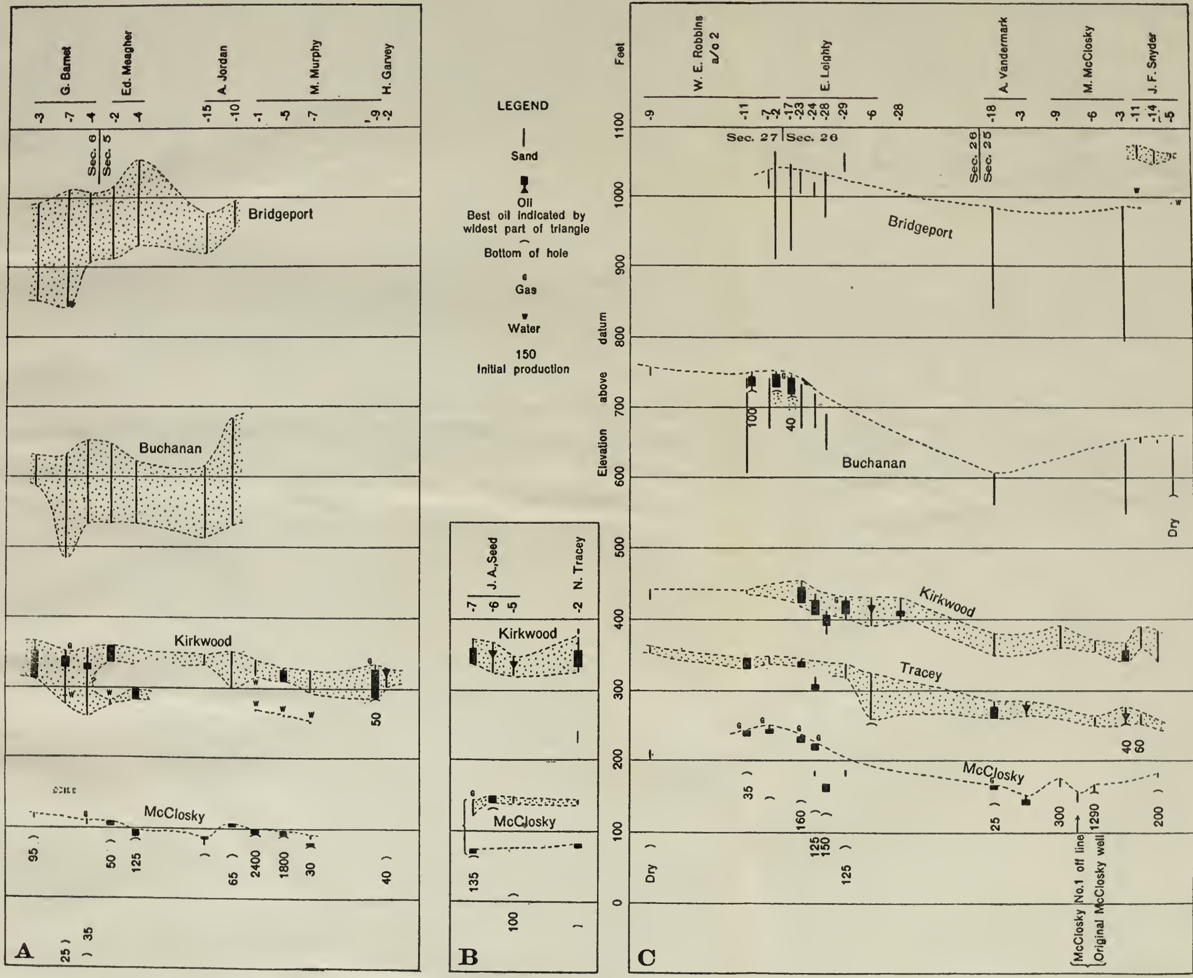

Sections in Vincennes quadrangle showing oil sands:

A. Through Murphy pool showing even bedding of the McCloskey as compared with the more irregular Tracey, Kirkwood, Buchanan, and Bridgeport sands.

B. Along north line of section 13, Lawrence Township, showing more than one McCloskey oil sand.

C. West to east across productive part of La Salle anticline along first tier of wells south of center of secs. 27, 26, and 25, T. 3 N., R. 12 W. (including original McCloskey well).

At the St. Francisville pool the rocks are lying very nearly flat but are rising at a low angle toward the southeast. The productive portion of the pool lies about 300 to 350 feet lower than the south end of the main field on the anticline. The eastward rise of the rocks noted in the wells at St. Francisville is reported by Mr. T. E. Savage, who has studied the geology of the region, to be visible also in the rocks at the surface, the eastward rise persisting to the eastern borders of the quadrangle. No good well records have been secured from the areas southeast of St. Francisville, consequently the continued rise to the east cannot be verified from well records on the deeper sands. The dry holes along the eastern side of the St. Francisville pool as developed in September, 1915, appear to be due rather to the pinching out of the particular sand which produces the oil than to the lowering of the structure. The rocks at the dry holes appear to be as high as elsewhere within the pool.

An important deep well, a record of which is published herewith, was drilled in the summer of 1915 on the Collison farm in the NW. ¼ NE. ¼ sec. 27, T. 2 N., R. 12 W. (Dennison Township). In this well, which has an elevation at the mouth of 443 feet, the top of the "Big Lime" was encountered between 2,000 and 2,065 feet below the surface. The Kirkwood sand with a show of oil lay at a depth of 1,861 feet, or 82 feet above datum. A show of green oil, correlated with the McClosky, was encountered in the upper part of the "Big Lime" at 2,119 feet, or 176 feet below datum.

A well near the west center of sec. 22 (Easterday farm) three-fourths mile northwest of the Collison well, encountered a water sand which is interpreted as the Kirkwood at 1,940 to 1,950 feet below the ground. This is 13 feet below datum. The formation here seems to be 95 feet lower than in the Collison well.

It appears from these records that the rocks at the Collison and Easterday wells lie 300 to 400 feet lower than on the anticline at the southern end of the oil field in sec. 2, T. 2 N., R. 12 W.

The detailed record of the Collison well proved to be the connecting link which made possible a revision of the correlation of the formations in the Allendale pool which lies near the southeastern corner of the quadrangle. From the few records of deep wells in the neighborhood of the Allendale field, it appears that the horizon of the Kirkwood sand lies roughly 1,500 feet below sea level, a little lower than in the Collison well. The correlation is made on the basis of the red shale and the limestone which commonly overlie the Kirkwood and which are encountered in these deep wells at depths 1,830 to 1,960 feet below the surface. The wells yielding data on the red rock are on the Mary B. Carson farm in the NW. ¼ sec. 28, T. 1 N., R. 12 W., one-half mile southwest of the south corner of the quadrangle; the C. F. Adams farm in the NE. ¼ NW. ¼ sec. 21, T.

1 N., R. 12 W., about one-eighth mile west of the quadrangle line; on the John H. Schafer farm, NW. corner sec. 15 (near the south end of the Allendale pool), and the Carlton Hershey farm near the center of sec. 34, T. 2 N., R. 12 W., one mile north-northeast of the northern end of the Allendale pool and between it and the Collison well. The records of these wells indicate that the rocks in the southwestern portion of the quadrangle lie essentially flat at a level 400 to 450 feet lower than the crest of the anticline in the main oil field and about 80 feet lower than the productive terrace at St. Francisville.

As has been stated in the description of the Allendale field, the new correlation places the Biehl sand, the producing sand of the Allendale field, not at the horizon of the Kirkwood in the Chester rocks, but at approximately the horizon of the Buchanan sand in the Pottsville formation. The Allendale pool is conditioned by a small local dome similar to those on the eastern flank of the anticline farther north, which has permitted the accumulation of oil. Practically nothing is known of the structure of the rocks along the southern border of the quadrangle except near the Allendale field. Several dry wells have been drilled, but no records are available.

Areas Favorable for Further Drilling

As a general statement it may be said that all the area east from the main field and as far south as the Murphy pool, secs. 4 and 5, T. 3 N., R. 11 W., is possible oil territory in the sense that small local domes here and there may be found. The rocks over the entire area lie relatively high as compared with those west of the anticline and in the basin in the southwestern corner of the quadrangle. Several small pools within this area have already been discovered, and the prospects are favorable that further drilling will reveal others. There is, however, no possibility of indicating in advance the exact points where drilling would be successful, and since any pools discovered are likely to be small, prospecting should be conservative. A slight extension of the eastern end of the Murphy pool seems probable; likewise, an extension of the St. Francisville pool to the east and southwest. If the eastward rise of the strata continues from St. Francisville to the eastern border of the quadrangle, as is indicated from the studies of the surface rocks, there is a prospect that almost anywhere in the eastern and southeastern portions of the quadrangle small local pools, conditioned by the presence of minor domes on otherwise flat-lying rocks, may be found. Here, as to the northeast, there is no possibility of indicating the exact locations of such pools, particularly in view of the fact that the alluvium of the Wabash valley covers the bed rock. In connection with the discussion of the possibilities of further development of this area, attention is called to the fact that the structural conditions under the eastern half of the Vincennes quadrangle are very similar to those of

the Birds quadrangle, though the oil is likely to be produced from a lower horizon. In both regions the rocks seem to lie nearly flat, dipping, however, at the low angle toward the east in the Birds quadrangle, and the accumulation of the oil is controlled by local features—in the Birds quadrangle by local thickenings of the sand at the oil horizon; in the northern part of the Vincennes quadrangle, apparently, by minor structural domes.

The data on the very few wells in the region indicates that there may be a fairly pronounced terrace south of the end of the main field in the southern halves of secs. 13 and 14, and in secs. 23 and 24, T. 2 N., R. 12 W. (Dennison Township). Though the finding of oil in this region can not be predicted with any great degree of confidence, it is believed that this is the most favorable area in the immediate vicinity for testing.

The Allendale field, it is believed, will be found to extend northward to the NW. ¼ section 3, and possibly still farther. There seems less likelihood that it will be extended eastward.

On the whole, the most favorable area in the entire quadrangle for immediate testing is believed to be the deep sands in the central part of the Allendale field. The Kirkwood, Tracey, and McClosky sands all lie underneath the Biehl sand, and since the Allendale field is on a distinct, though small, anticline, the conditions for the accumulation of oil in the lower sands are favorable. The first test wells should be drilled on the higher parts of the dome, as shown on the contour map (Pl. VIII). The depths at which the deep sands are to be expected are given in connection with the description of the Allendale field.

INDEX